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REPORT OF THE CHIEF OF THE BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE, 1937

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE,
Washington, D. C., September 15, 1937.

Hon. HENRY A. WALLACE,
Secretary of Agriculture.

DEAR MR. SECRETARY: I submit herewith a report of the work of the Bureau of Entomology and Plant Quarantine for the fiscal year ended June 30, 1937.

Sincerely yours,

LEE A. STRONG, *Chief.*

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INTRODUCTION

The organization of the Bureau activities has continued along substantially the same lines and with the same division leaders as during the previous year. The special investigations begun last year with allotments from processing taxes collected in Hawaii and Puerto Rico were concluded. A small amount of funds available for work in Hawaii remains available and will be used for special studies having a direct bearing on the control of fruitflies in Hawaii during the fiscal year 1938.

As in the preceding year, activities concerned with the eradication and control of plant pests were materially expanded by allotments of emergency funds for relief. The results of the work done under these special allotments are discussed under appropriate headings and include the following activities: Gypsy month control, brown-tail moth control, Dutch elm disease eradication, barberry eradication, white pine blister rust control, citrus canker eradication, phony peach disease control, eradication of peach mosaic, elimination of wild cotton in southern Florida, and the destruction of Thurberia plants in southeastern Arizona.

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Camps operated by the Civilian Conservation Corps have cooperated in the control of certain insect pests and plant diseases. These activities have been made a regular part of the activities of the camps, the technical advice being supplied by this Bureau. The active project of some few camps has been directed entirely toward the control of such pests, including the gypsy moth in the New England States, and toward the eradication of the Dutch elm disease in New Jersey. Some camps have cooperated in the control of grasshoppers and the Mormon cricket. Others have engaged in the control of insect pests in forests. To aid in making the surveys needed to plan such work, small allotments were made to the Bureau from appropriations for emergency conservation work to conduct investigations having a direct bearing on the work done by the camps. A small allotment was also made to enable the Bureau to advise camps regarding the control of mosquitoes, particularly the work done from camps in the States of Delaware and Maryland.

PUBLICATIONS AND EDITORIAL WORK

During the year 506 manuscripts were presented for publication and 463 were approved, 83 being submitted to the Department for publication and the remaining 380 to outside journals. There remained on hand at the end of the year 142 manuscripts, 103 of which were under consideration in the Bureau, 27 were in the Office of Information awaiting publication by the Department, and the remaining 12 were in press at the Government Printing Office. Of the 103 in the Bureau, 52 were being considered for publication by the Department and the remaining 51 for publication in outside periodicals.

LIBRARY

The loan and reference work connected with supplying books and periodicals for the scientific staff of the Bureau has increased approximately 15 percent. As a part of these activities the library staff has prepared several special bibliographies to aid the investigators, including a list of articles reporting the effect of electricity on insects, and one listing papers on ants attacking forests, with special reference to *Formica exsectoides*. Entomology Current Literature has appeared regularly every 2 months, with 135 pages this year as compared with 117 last year. The outstanding bibliographic work for the year was the completion of Index V of American Economic Entomology for 1930–34, a compilation of some 40,000 references. This manuscript is to be published with the cooperation of the American Association of Economic Entomologists and is expected to be printed late this fall.

INSECT PEST SURVEY AND INFORMATION

The survey added to the permanent files on the distribution and abundance of insects 12,000 notes on American insect pests and 7,000 notes on foreign pests, bringing the total now available for consultation to 259,650 notes. The work of the year brought the number of insect pests of foreign countries not known to be in the United States to over 20,000 kinds, which now exceeds the number of insect pests recorded from this country by nearly 1,000.

The monthly Insect Pest Survey Bulletin was augmented by supplements on Insect Pests from Costa Rica in 1935, Colonization of Parasites of the European Corn Borer, Chinch Bug Abundance in Hibernation Quarters, European Corn Borer Status in 1936, European Corn Borer Surveys, Distribution of the Species of Grasshoppers in the 1936 Outbreak, Hessian Fly Infestation, Alfalfa Weevil Survey, The Periodical Cicada, and Distribution of Grasshoppers in 1936.

One hundred and twenty-eight articles on entomological and quarantine subjects were released to the press, and 70 radio talks were put on the air. The preparation of film-strip material covered seven new subjects. Two motion pictures were completed, one on the periodical cicada and one on the screwworm. Entomological exhibits were shown at the International Exposition in Paris, at the American Medical Association in Atlantic City, N. J., at the annual meeting of the American Association of Economic Entomologists in Atlantic City, N. J., at the North American Wildlife Conference in St. Louis, Mo., at the International Horticultural Exposition in Chicago, Ill., at the Florida State Fair, at the Twelfth Annual National Shade Tree Conference in Boston, Mass., at the National Association of Exterminators and Fumigators in Cleveland, Ohio, and at the American Royal Livestock Show at Kansas City, Mo. Two new State-fair exhibits were prepared on different phases of termite control.

Cooperative extension work in entomology was supervised under the direction of the Bureau and the Office of Cooperative Extension Work.

Approximately 222,600 copies of publications were distributed, exclusive of those sent out on regular mailing lists and miscellaneous mimeographed material.

FRUIT INSECT INVESTIGATIONS

APPLE INSECTS

In the search for insecticides which may be substituted for lead arsenate in the control of the codling moth, approximately 250 new compounds, chiefly organic materials supplied by the Division of Insecticide Investigations, were given preliminary test at the Beltsville, Md., laboratory. In practically all cases the results were so poor that the materials were eliminated from further consideration; a few warrant further laboratory study.

Certain nicotine combinations, particularly nicotine-bentonite, have continued to give encouraging results in field and laboratory, and one form of this material is being tested on a semicommercial scale in orchard plots of about 2½ acres each in southern Indiana. A number of growers have been very much impressed by the results with the nicotine bentonite and are using it on portions of their acreage. If found practical, this material will be especially useful on early varieties such as the Yellow Transparent, which does not lend itself very readily to the washing process for residue removal. The high cost of nicotine-bentonite is, in part at least, offset by additional benefits in the control of other insects and by the more favorable effect on the tree than results from the use of lead arsenate.

In the Pacific Northwest phenothiazine has continued to give outstanding control of the codling moth, but the difficulties formerly pointed out have not yet been overcome. The chief disadvantage is the serious skin irritation suffered by some of the men doing the spraying, and by the men who later work in the trees thinning or harvesting. A minor disadvantage is a more or less unfavorable effect on the coloring of the fruit. In the East and Middle West the results with this material are still irregular but have offered sufficient encouragement to justify further work.

At Vincennes, Ind., more use is being made of a "field-laboratory" method of testing insecticides. Field plots are laid out and sprayed as usual, and at intervals the apples are taken to the laboratory and artificially infested with a known number of newly hatched codling moth larvae. The experiments are thus independent of the natural infestation, which is often very irregular within the same orchard. This method gives a running picture through the season of the relative effectiveness of the materials tested. The detailed information resulting from the use of this method is of great value in supplementing that obtained by the usual methods of field testing, in which the results are judged largely by the condition of the fruit at harvest time.

The program of recolonization of the codling moth parasite *Ascogaster quadridentatus* Wesm. has been completed. A large number of living adults of the eastern parasite *Phanerotoma tibialis* Hald. have been sent to Parma, Idaho, for liberation in an orchard which is being used at that point for a parasite project in which this Bureau is cooperating with the Idaho Agricultural Experiment Station, and a small colony of the native parasite *Aenoplex carpocapsae* Cushm. has been sent to the same place. The European codling moth parasite *Ephialtes extensor* Tasch. was received in small numbers from the Division of Foreign Parasite Introduction and was propagated in the laboratory, and small colonies were liberated in New Jersey and Idaho. Studies of the cocoon parasite *A. carpocapsae* showed that breeding nearly ceases during July and August, but becomes normal again in September. After being quite abundant in certain orchards in southeastern Illinois in 1935, this species virtually disappeared from the same orchards in 1936.

The program of distribution of *Aphelinus mali* Hald., a parasite of the woolly apple aphid, to the Western States in which this effective beneficial insect was not already present, has been completed.

Studies of the biology and seasonal history of the pear thrips in the Northwest have indicated that the time of emergence from hibernation, with reference to the blooming period, varies considerably from year to year; and this makes the proper timing of spray applications difficult, although, when properly timed, applications of nicotine in several combinations have given very large reductions in the losses caused by this insect. Studies of the part played by

the thrips in the production of the russet or scab type of injury to prunes did not give conclusive results. It is apparent that both the thrips and mechanical injuries are in part responsible for this condition, but their relative importance has not yet been fully determined.

PEACH INSECTS

During the summer of 1936 a study was undertaken of the insects that infest peach orchards where the phony peach disease is found under conditions of natural spread, in an effort to obtain circumstantial evidence pointing to an insect or insects which may be responsible for the spread of this disease. In order to carry on this work a mobile research laboratory has been installed in a trailer of the usual tourist type. This is drawn by a motortruck which carries a power unit to furnish electric current for lighting and for the operation of equipment. In less than 8 months during 1936 this laboratory traveled more than 10,600 miles and collected 3,709 lots of insect material from peach orchards at 60 locations in 11 States. To have conducted the same amount of work by the use of the usual type of laboratory quarters would have required several times the personnel, and the maintenance of a number of seasonal or temporary laboratories. In the spring of 1937 a second unit was purchased and equipped for use in a similar survey of peach orchards in areas affected by the peach mosaic disease in the Southwestern States.

As in previous years, special attention has been given to the introduction and colonization of foreign and domestic parasites of the oriental fruit moth, in cooperation with numerous State agencies. During the calendar year 1936 eight shipments of parasite material were received from Japan, imported by the Division of Foreign Parasite Introduction. Out of this material 30,406 living adults of 15 different species of primary parasites were reared. Many of these were further propagated in the laboratory. During 1936, 186 releasements of 42,138 parasites were made in 14 different States. Two hundred and fifty-eight recovery collections were made by the Bureau and cooperating State workers in 16 different States. This work is being continued during the calendar year 1937, with greater emphasis on recovery collections in the vicinity of previous releases, in order to obtain more complete information on the status of the introduced parasites.

In field experiments with substitutes for lead arsenate for the control of the plum curculio, both barium fluosilicate and cryolite caused considerable damage to peaches, similar to the injury that occurred during the season of 1935, in spite of the fact that the materials were used in fewer applications than in 1935. The foliage was uninjured.

Of a number of water-soluble compounds tested against the peach borer, dichlorethyl ether has given a very high degree of control when applied during February and March. At higher temperatures in both fall and spring this material has given variable results, and has caused a certain amount of injury. Dichlorethyl ether has also given promise for use as a soil fumigant against the plum curculio.

GRAPE INSECTS

During the 1936 season phenothiazine gave very satisfactory control of the grape berry moth, with no seriously objectionable staining of the fruit at harvest time, but it increased somewhat a tendency toward russeting of the berries. As was the case in the experiments with codling moth control, phenothiazine had a very unfavorable effect on certain of the operators who were engaged in applying it. Several forms of nicotine-bentonite gave a considerable degree of control but caused some objectionable staining, which was particularly serious in the case of a tank-mixed nicotine-bentonite.

Further experiments with burning, carried on in the spring of 1936, confirmed the previous year's conclusions that an important reduction in the population of grape leafhoppers (*Erythroneura comes* (Say)) can be obtained by burning over the areas surrounding the vineyards in which the leafhoppers are passing the winter. In the vineyard in northern Ohio, around which the work was conducted, the leafhopper infestation was the lightest in many years, in marked contrast to other vineyards in the same locality, where the leafhopper infestations were abnormally severe.

In cage experiments phenothiazine gave practically complete kill of the grape rootworm and was apparently more effective than the arsenicals. Nicotine-bentonite, as in the preceding year, was not very toxic to the rootworm adults.

NUT INSECTS

A new laboratory was established in the spring of 1937 at Monticello, Fla., in cooperation with the Florida Agricultural Experiment Station for a study of pecan insects. At the outset special attention is being directed to the control of the pecan nut casebearer. The results obtained in the control of this insect in the spring of 1937 by the use of nicotine sulphate in combination with white oil emulsion were in line with those previously reported by the Albany, Ga., laboratory. That laboratory is now giving all of its attention to the hickory shuckworm on pecan, for the control of which adequate measures are not yet available. Special emphasis is to be placed on the relation of natural enemies to the control of this insect and to possible cultural methods of controlling it.

In experiments with the obscure scale in northern Louisiana it was learned that oil sprays have an important residual effect which is not evident until the female scales reach maturity. In orchards sprayed with 2- or 3-percent lubricating-oil emulsions during February and March, only from 1.3 to 9.5 percent of the females that reached the appearance of maturity were able to lay eggs, whereas in unsprayed trees in the same orchards, 66 to 86 percent of the mature female scales laid eggs in a normal manner. This means that it is possible to obtain satisfactory control of the obscure scale in pecan orchards with low strengths of oil emulsion, which is fortunate in view of the susceptibility of pecan trees to injury by oil sprays.

The use of lead arsenate as a spray at a strength of 3 pounds in 100 gallons of water, with 3 pounds of hydrated lime, has given very effective protection of young pecan trees from attack by the adult May beetles of the genus *Phyllophaga* in northern Louisiana. In most cases four or five applications were made at frequent intervals, but it is believed that the beetles should be well controlled by three applications put on during the early part of their feeding period. Observations have indicated that most of the protection results from a repellent action on the part of the spray. A little foliage injury developed from five applications, but this was not at all serious.

DRIED-FRUIT INSECTS

The motor-driven raisin cleaner developed by the Fresno, Calif., laboratory in 1935 was further improved, and it appears to be particularly effective in removing infestation of the raisin moth from Sultanina (Thompson Seedless) raisins, reducing the numbers of the insects in many cases more than 90 percent, and in addition removing most of the sand and debris. The paper trays on which the raisins are now extensively dried prevent infestation to a certain extent, and by the use of the paper trays, the cleaning machine, and shade-cloth covers over the boxes of raisins while temporarily stored on the ranch, the delivery of comparatively clean raisins now appears possible. Dried pears practically free from infestation were obtained by covering the fruit with cloth during the final stages of drying, confirming the results of previous experiments with various dried fruits. In Arizona, cotton-cloth extensions on the paper rain covers used for dates gave promise of success in the exclusion of certain insects that have been attacking dates in the final stages of ripening or drying while still on the tree.

The practical utilization of cotton cloth for the prevention of insect infestation of dried fruits while being held in stacked trays on the ranches is being stimulated by a cooperative project carried on by the Agricultural Extension Service of the University of California. For this work about 20,000 yards of cotton cloth have been furnished by the Agricultural Adjustment Administration as a part of a cotton-diversion program. This is being distributed to representative growers, and detailed records will be kept of the results.

In addition to the mulberry, which in most localities is practically the only food available to the raisin moth in the spring during the first generation, Mission figs were found in one locality to be of considerable importance in the building up of the raisin moth population early in the season. For the first time serious injury by larvae of the raisin moth to fresh grapes on the vines was observed.

SUBTROPICAL FRUIT INSECTS

Field experiments to determine the effect on the trees of tartar emetic when used as a bait spray on citrus trees have been continued by the Orlando, Fla., laboratory, in cooperation with other bureaus. Plots of trees have been sprayed

at 10-day to 20-day intervals with mist sprays containing 4 pounds of tartar emetic and 5 gallons of molasses in 100 gallons of spray. By the end of June 1937 certain of these trees had received 69 successive applications. Careful measurements of trunks, branches, leaves, and fruit made by workers of the Bureau of Plant Industry revealed no injurious effects, and the analyses of juice samples made by the Bureau of Chemistry and Soils showed no differences in quality that could be attributed to the use of the spray.

Much attention has been given to the development of a standardized procedure for laboratory experimentation with the California red scale in order to overcome the extreme variability which has thus far been evident in the results of experimental work. In some cases in the past the mortality of scales on individual lemons fumigated at the same time has ranged from 50 to 100 percent. Definite progress is being made toward the development of methods that will overcome this variability, giving more consistent results that can safely be used for drawing conclusions.

Populations of the California red scale derived from areas where they are said to be resistant and other populations from areas where they are said to be nonresistant to cyanide fumigation have been maintained under identical conditions in the insectary at the Whittier laboratory, but completely isolated from each other. Periodic fumigations are being made to determine the relative susceptibility of the different strains. Preliminary results indicate that, a year after the establishment of the strains in the insectary, the initial differences in susceptibility still exist.

Studies of the biology of the California red scale have given more accurate information on reproduction than has hitherto been available. The greatest number of young produced by a single female was 300. One scale produced young over a period of 287 days. Because of this long period of reproduction, the generations of the scale insect overlap to a considerable extent.

JAPANESE AND ASIATIC BEETLES

In the older areas of infestation the emergence of adult Japanese beetles began somewhat earlier in 1936 than in 1935 but did not reach a peak so quickly. There was a general increase of beetle abundance within the New York, N. Y., metropolitan area, and a continuance of large areas of severe injury in north-central New Jersey, eastern Pennsylvania, and, to a modified extent, in southwestern New Jersey, with the development of very serious injury in northern Delaware, northeastern Maryland, and extreme southeastern Pennsylvania. In southern New England the population showed a definite increase in 1936 as compared with 1935. There was, on the other hand, a general decrease in injury in the older infested area in the general vicinity of Philadelphia, perhaps in part due to severe mortality in certain localities during the winter of 1935–36.

As bait materials for the adult beetles, certain grades of Ceylon and Java citronella oil appeared to be more attractive to the beetles than the grade of geraniol used as a check bait. This held true in various types of traps and dispensers. Citronella oil is cheaper than geraniol and appears to be a satisfatory substitute attractant for the beetle.

Further improvements have been made in the rosin-residue emulsion as a sticker for use with derris, which is the most promising substitute for lead arsenate as a repellent for the beetle. Out of a large number of materials used with derris in an effort to decrease the rate of its decomposition by light or its removal by rains, those which caused the derris to be most persistent reduced at the same time its value as a repellent, with the exception of sulphur, which appeared to increase its value. Field experiments with derris and rosin-residue emulsion, and with lime and aluminum sulphate now recommended for the protection of early-ripening tree fruits, confirmed previous results and support existing recommendations.

Various materials have been tested to determine their influence on the effectiveness of lead arsenate in the control of larvae in the soil. The phosphates of sodium, potassium, or ammonium significantly increased the solubility of lead arsenate in the soil, and the phosphates of potassium and sodium also increased its insecticidal action when the lead arsenate was used at dosages of less than 1,000 pounds per acre, confirming results of the previous year. The phosphates of calcium, on the other hand, increased neither the solubility of the lead arsenate nor its toxicity to the grubs. The addition up to 10,000

pounds per acre of greensand marl, which is promising for use in soils to overcome or reduce arsenical injury to plants, did not significantly modify the insecticidal action of lead arsenate within 30 days after application. Further studies of the use of lead arsenate in various types of soil from different localities have shown that the character of the soil has a considerable influence on the effectiveness of the lead arsenate treatment, but that 1,500 pounds per acre, as at present recommended for nursery treatment, is adequate in most soils usually encountered. Some modification of recommendations for certain soils may, however, be necessary.

A large number of females of the imported hymenopterous parasite *Tiphia vernalis* Roh. have been collected in the field from well-established colonies and recolonized in other localities. During the early summer of 1937, 162 colonies, totaling 16,553 females, were placed in New Jersey, Pennsylvania, Delaware, Maryland, New York, and the New England States. With colonies that were established in 1933, parasitizations as high as 58 percent have been found. Among the imported parasites, this species appears to be by far the best adapted to the biology of the Japanese beetle.

The introduced parasite *Tiphia popilliavora* Roh. is well established in many localities, and during the summer of 1936 field-collected females to the number of 4,818 were recolonized at 44 points in New Jersey, Pennsylvania, and Delaware. It has been found that a number of adults of this species have not emerged until the second or third year following that in which the cocoons were formed. The form of *T. popilliavora* first introduced is, unfortunately, rather poorly synchronized with its host in the Moorestown, N. J., area. Special attention has therefore been given to a Korean strain of this parasite, which emerges later, at a time much more favorable to parasitization. During 1936 nine colonies of this strain were liberated in New Jersey and Pennsylvania.

Further studies have been made of the diseases attacking the immature stages of the Japanese and Asiatic beetles in the soil. Examinations in the field at frequent intervals during the season showed in the early spring a low percentage of diseased grubs; the proportion increased rapidly to a peak of 36 percent late in June. The disease rate fell rapidly as the new brood of larvae developed, then rose to a maximum of about 13 percent in September, and fell off again as cold weather came on. Observations on field plots in which types A and B milky diseases were artificially introduced in 1935 indicated the establishment of the disease with spring introductions, the disease rate increasing to as high as 44 percent by June 1936. Similar plots started in the fall of 1935 indicated that fall is not a satisfactory time for introducing a disease organism, because of falling temperatures and unfavorable weather conditions.

Material of *Tiphia sternata* Park, a parasite of the Asiatic garden beetle, was received from the Division of Foreign Parasite Introduction and increased in the laboratory for further colonization. Fourteen hundred adult females of this species were liberated at five centers in Pennsylvania and New Jersey. At least a few of this species passed the winter of 1936–37 successfully, as evidenced by the recovery at Palmyra, N. J. *T. asericae* A. and J. was likewise recovered in the spring of 1937.

In order to keep in touch with the progress of the Japanese beetle in the more recently infested areas and to determine its behavior under new conditions, as a basis for studies of control measures in connection with efforts to retard its spread, a new field laboratory has been established at Salisbury, N. C. For the present the work deals primarily with the biology, food plants, and behavior of the beetle under conditions in the outer zone of spread; this is to be followed as soon as feasible by experiments with the control of the insect under the new conditions.

FRUITFLY INVESTIGATIONS

The research work on fruitflies has been continued as in the past in the laboratories in Mexico City, Honolulu, Mayaguez, P. R., and the Canal Zone.

In Mexico work has been done on the sterilization of fruit by refrigeration to guarantee its freedom from living eggs and larvae of the Mexican fruitfly. Studies at 34° to 35° F. resulted in adults emerging after 16 days of exposure. Puparia were formed by larvae which had been exposed for 17 and for 18 days, but no adults emerged from these puparia. The results indicate that the

Mexican fruitfly is more resistant to low temperatures than are the other fruitflies so far studied.

The resistance of adults to low temperatures was studied with an instrument designed by W. E. Stone which permits the reproduction of a continuous temperature record taken in any locality. The exposure covered 6 days of cold weather during which the temperature ranged as low as 26.9° F. Only 30 percent of the young flies used were killed and the remainder subsequently infested fruit in a normal manner.

Spraying experiments with 4 pounds of tartar emetic and 20 pounds of granulated sugar in 100 gallons of water gave promising results in reducing the populations of the Mexican fruitfly, as high as 90 percent reduction being obtained in one instance. Sprayed grapefruit trees held their crop well on into June, whereas the entire crop fell from the unsprayed trees early in the season.

In Hawaii low-temperature sterilization experiments with fruits infested by the Mediterranean fruitfly were continued. At 33° F. no larvae were able to mature to adults after 10 days of exposure. At a temperature of 36.5° no adults were obtained after an exposure of 12 days. The early stages of the melonfly appeared more susceptible to low temperatures, since no adults were obtained at 36.5° after an exposure of 10 days. In the treating room there was a fluctuation of 1°, so that for short periods the larvae were held at slightly below 36°.

Studies were conducted with papayas to determine their susceptibility to attack by the melonfly. Both ripe and commercially picked papayas proved to be definitely susceptible.

Studies with screen barriers against the drift of melonflies into cucumber plots have shown a definite reduction in infestation. The barrier cost, however, has not been offset by the returns. More promising results from the monetary viewpoint were obtained with a nicotine spray.

Studies on holding fruits infested by the Mediterranean fruitfly in sealed containers showed that 100 percent mortality of the early stages of the insect can be obtained in this way, but effects of such treatment on sound fruits have not as yet been obtained.

In Puerto Rico studies on low-temperature sterilization of fruit infested by the two species of fruitflies *Anastrepha suspensa* Loew and *A. acidusa* Walk. have been continued. Work at 32° F. has shown that 11 days of exposure at this temperature will prevent the early stages from maturing to adults. Later studies at 34° F. gave complete mortality of the early stages after exposure of 13 days at this temperature. Studies at 36° F. were inaugurated and show that larvae exposed to this temperature for a period of 15 days are still able to form puparia. No adults, however, have so far been obtained after an exposure of 12 days.

Sterilization studies with the vapor-heat process, exposing fruits to 110° F. for 8 hours with an approach period of 8 hours before the temperature of 110° is reached, showed that the Puerto Rican species of fruitflies require a slightly longer period for a complete kill to be obtained by this method than does the Mediterranean fruitfly, since there were a few survivals after 8 hours.

MEXICAN FRUITFLY CONTROL

INFESTATIONS

Traps were used extensively on this project in Texas to determine the extent of the adult population of the Mexican fruitfly (*Anastrepha ludens* Loew). Few flies were taken before the first of the year. In January, however, it became apparent that there were many more flies in the area than during any previous season, and that if conditions remained favorable, larval infestations might become general. The number of flies recovered from traps continued to mount throughout February, but no infested fruit was found until toward the close of the month. Early in March the condition changed radically. Relatively few flies were trapped, but larval infestations were found in all districts. In April the fly population again mounted, and the number of larval infestations decreased. In May only a small amount of infested fruit was found during the tree-to-tree inspection work, and none was discovered in June. Throughout these 2 months the fly catch continued to decline to a point where only four flies were trapped the latter half of June.

The records of the infestation of *Anastrepha ludens* in the Rio Grande Valley suggest it may be the result of flies coming from Mexico during the winter months rather than a continuing permanent population in the area. If such a migratory movement occurred this season it evidently reached a peak during the first half of February, the incoming flies disappearing by the middle of March. The larger number of flies taken during April and May may have resulted from larval infestations in February and March.

Adult and larval infestations are shown by districts in table 1.

TABLE 1.—*Infestations of the Mexican fruitfly in Texas, fiscal year 1937*

District	Adults trapped		Larval infestations (premises)	District	Adults trapped		Larval infestations (premises)
	Specimens	Premises			Specimens	Premises	
Mission	404	43	221	Raymondville	8	4	2
McAllen	675	35	82	Harlingen	98	25	43
Edinburg	780	38	89	San Benito	110	30	38
Pharr-San Juan-Alamo	491	31	108	Brownsville	46	12	45
Donna	760	29	85	Falfurrias	75	10	9
Weslaco	592	36	136				
Mercedes	276	27	70	Total	4,714	349	1,062
La Feria	399	29	134				

OTHER SPECIES OF FRUITFLIES TRAPPED

Other species of *Anastrepha* and *Toxotrypana* are frequently taken in traps along with *A. ludens*. The host of one fly (*A. pallens* Coq.) is known; it is *Bumelia angustifolia*, a noneconomic sapotaceous plant. No local hosts for the other flies have been found, and it is believed that the occurrence of these flies in this area is likewise the result of a migratory tendency. Flies were taken throughout the area, as shown in table 2.

TABLE 2.—*Other fruitflies trapped in Texas, fiscal year 1937*

District	*Anastrepha serpentina*	*Anastrepha acidusa*	*Anastrepha pallens*	*Anastrepha* species Y	Other *Anastrepha* species	*Toxotrypana curvicauda*
Mission	6	5	382	20	2	22
McAllen	19	6	143	25	4	26
Edinburg	7	6	1,871	35	5	14
Pharr-San Juan-Alamo	15	11	311	26	0	8
Donna	13	15	182	28	4	21
Weslaco	35	11	486	29	5	15
Mercedes	7	3	277	10	0	8
La Feria	7	5	392	18	0	9
Raymondville	0	1	270	4	0	0
Harlingen	6	4	553	12	1	3
San Benito	9	7	209	7	2	3
Brownsville	1	0	179	5	0	1
Falfurrias	13	5	387	14	0	1
Total	138	79	5,642	233	23	131

GROVE AND PACKING-HOUSE INSPECTIONS

The purpose of grove inspections is twofold. Inspections are made to determine if the fruit is free from larval infestations and also to enforce the sanitary provisions of the quarantine regulations. This season the issuance of permits to harvest fruit was based upon the condition that the fallen fruit had been picked up and properly buried at weekly intervals. Packing houses are inspected regularly to enforce quarantine sanitary requirements and to check records of origin of fruit harvested and shipped.

The monthly summary of these inspections, together with certain information relative to trapping and the removal of alternate host-fruit trees, is shown in table 3.

TABLE 3.—*Field inspections in Texas, fiscal year 1937*

Month	Grove inspections	Premises trapped	Traps operated	Trap inspections made	Secondary host fruit	
					Trees destroyed	Premises cleaned
July	565	511	9,007	24,232	3	3
August	323	501	8,995	34,781	2	1
September	654	480	8,616	27,075	3	2
October	8,386	381	6,300	17,513	11	2
November	14,137	269	5,099	18,672	25	5
December	13,664	304	5,749	22,722	2	2
January	12,749	321	5,947	20,725	0	0
February	13,151	334	5,952	19,430	0	0
March	8,570	311	5,836	23,728	2	1
April	1,728	293	5,695	22,001	102	40
May	38	547	6,489	23,258	95	33
June	0	672	7,819	33,557	8	3
Total or average	73,965	394	6,792	297,694	253	92

ACTIVITIES IN MEXICO

Large quantities of various kinds of fruit are shipped regularly from the interior of Mexico to the border. Frequently part of this fruit is infested with fruitfly larvae. In preceding years larval infestations have developed in local hosts in the border towns. To reduce infestations in Mexico and prevent their spreading to Texas groves, one inspector and one laborer are stationed at Matamoros to collect infested fruit and operate traps. The success of this phase of the work is proved by the fact that in spite of the wormy fruit being sold there, no larval infestations have been detected in any fruit produced in Matamoros during the last 4 years. Traps are operated continuously, and whenever adults are taken, poison spray is applied to the trees.

Table 4 shows the number of adults and larvae taken in Mexico during the year.

TABLE 4.—*Adults of Anastrepha spp. trapped and larvae of the same collected in Mexico, fiscal year 1937*

Location	Adults trapped						Larvae collected in imported fruit			
	Anastrepha ludens	*Anastrepha serpentina*	*Anastrepha acidusa*	*Anastrepha striata*	*Anastrepha* species Y	*Anastrepha pallens*	*Anastrepha ludens*	*Anastrepha serpentina*	*Anastrepha acidusa*	*Anastrepha striata*
Matamoros	18	0	1	1	1	10	3,498	196	3,057	50
Reynosa	12	0	0	0	0	2	0	0	0	0
Reynosa brush	0	3	2	0	0	136	0	0	0	0
Total	30	3	3	1	1	148	3,498	196	3,057	50

ROAD TRAFFIC INSPECTION

Two road stations were operated on the main highways leading from the regulated area. The personnel of these stations inspected all vehicles and confiscated fruit moved in violation of quarantine regulations. The fruit passing these two stations approximated 5,000 carlots. Confiscations totaled 456 lots of fruit. In only a few cases did it appear that the drivers of vehicles from which this fruit was taken were attempting to violate quarantine regulations. In only one case were charges filed and a fine assessed.

SHIPMENT OF FRUIT

The commercial fruit produced in the Rio Grande Valley increased from 9,447 equivalent carlots for 1935–36 to 30,701 equivalent carlots for 1936–37. This increased production taxed the packing and shipping facilities of the industry as well as the inspection force on this project to certify it for ship-

ment. All regular means of transportation shared in the increase, and, in addition, 193 equivalent carlots were moved by steamer to seaboard markets. This is the first season that ocean transportation has been available from valley ports.

Table 5 shows the shipments of fruit from this area for the seasons 1932–33 to 1936–37.

TABLE 5.—*Equivalent carlot shipments of citrus fruit from the lower Rio Grande Valley, Tex., and total production in stated years*

Shipping season	By rail		By truck		By boat		By express and passenger car	Grapefruit canned	Commercial production
	Grapefruit	Oranges	Grapefruit	Oranges	Grapefruit	Oranges			
1932–33	2,897	230	880	586	----	----	101	127	4,821
1933–34	1,748	114	1,236	877	----	----	99	240	4,314
1934–35	4,617	225	1,731	1,095	----	----	239	1,131	9,038
1935–36	4,262	600	1,454	1,182	----	----	267	1,682	9,447
1936–37	15,616	2,729	2,578	2,351	176	17	532	6,702	30,701

CANNING PLANTS

The grapefruit canning industry consumed 25 percent of the grapefruit produced. This amounted to 6,702 equivalent carlots. Practically all the plants were equipped with steam sterilizers for sterilizing canning-plant debris. This equipment was designed by workers in the Bureau in order to kill any larvae that might have been in fruit sent to a cannery. The increase in the volume of fruit processed since 1932 is shown in table 5.

JAPANESE BEETLE QUARANTINE AND CONTROL

TRAP SCOUTING IN NONREGULATED TERRITORY

Trap scouting for the Japanese beetle was carried on during the summer of 1936 in 324 towns and cities in 19 States, an increase of 111 communities and 6 States over those trapped in the previous year's annual survey of nonregulated territory. Approximately 103,500 traps were set, doubling for the second consecutive year the number of traps set as compared with the previous summer's trapping program. This extensive survey was made possible by the use of 90,000 lightweight, collapsible traps, developed by project personnel and manufactured at the Bureau's warehouse in Pennsylvania. Savings of 75 percent in manufacturing cost, 80 percent in freight cost, and 25 percent in set-up and removal expense were effected by the use of these traps.

Results of trapping in 1936 disclosed 36 first-record infestations, 16 of which were in Maryland, 3 in West Virginia, 2 each in Georgia, Indiana, Kentucky, North Carolina, Ohio, and Virginia, and 1 each in Maine, Michigan, New York, Pennsylvania, and Tennessee. With exceptions of first-record infestations at Jessups, Millersville, New Market, Point of Rocks, and Riviera Beach, Md., Grafton and Hollidays Cove, W. Va., Sharon, Pa., and Brewer, Maine, all these initial finds involved fewer than 10 beetles each. Beetles were caught in 108 communities in which incipient infestations had been determined. Trapping in 183 cities and towns gave negative results.

Initial trapping in four localities in Tennessee resulted in the capture of four beetles at Bristol.

Capture of one beetle each in Augusta and Savannah was the net result of trapping resumed in Georgia after a lapse of 4 years.

In Greenville, S. C., trapping revealed a reduction from 89 beetles in 1935 to 33 beetles in 1936. All but one of these appeared in the area where delayed applications of lead arsenate were made in the spring of 1936. In Charleston, S. C., where trapping was with negative results in 1935, 11 beetles were caught. These were scattered in the southeastern section of the city near the water front and freight terminals, a section in which lead arsenate was applied in 1931. None of the 1936 finds were in the blocks previously treated.

Traps set in 35 communities in North Carolina revealed infestations in 15 localities. Small infestations failed to reappear in seven towns. The catch at Winston-Salem showed a reduction from 109 beetles in 1935 to 37 beetles this

season. Initial finds of one beetle each were made at Elizabeth City and Wilson.

This season's trapping in Kentucky was the first undertaken in that State. Five cities were trapped. Two beetles in Louisville and one in Lexington were the net results of trapping in the State.

Beetles were caught in 9 of the 10 communities trapped in West Virginia; Fairmont, Parkersburg, Clarksburg, and Chester, all under a State quarantine since April 15, 1936, had the most substantial increase. Catches paralleling those of last year were made at Huntington, Martinsburg, Princeton, and Wheeling. One beetle was trapped for a first record at Charleston. Reported infestations at Grafton and Hollidays Cove were confirmed by hand collections.

Extensively scattered trapping throughout the nonregulated sections of Maryland turned up 16 first-record infestations, the most important being at Jessups, Millersville, New Market, and Riviera Beach. Carry-over infestations were disclosed at eight other points.

Trapping at Erie, Pa., revealed a still further reduction in catches for the fourth consecutive year. Only a small percentage of the 45 beetles caught came came from the previously treated area. A first record at Sharon and an increase to 15 beetles at Warren, where 1 beetle was caught in 1933, were the net results of trapping at 9 communities in northwestern Pennsylvania.

An increased number of traps in Cleveland, Ohio, netted 1,193 beetles as compared to 13 caught in 1935. Small infestations at four other Ohio points failed to reappear. However, there were uniform increases in 11 cities, those of largest proportion being in Cleveland, Youngstown, Hills and Dales, Steubenville, Toledo, Marietta, and East Liverpool. The catch at Cleveland was concentrated chiefly on the east side some distance from the network of railroads bordering the Cuyahoga River; that at Youngstown was concentrated in a limited section near fields favorable to larval development; that at Steubenville, between the Ohio River and the railroad yards; and that of East Liverpool in the vicinity of railroad terminals. First-record infestations of seven beetles each were found at Gallipolis and Mansfield. Approximately half the expense of trapping the 35 communities in Ohio was borne by State authorities.

Collections at Buffalo, N. Y., with a 400-percent increase in the number of traps set, mounted to 214 against 47 for 1935. Practically all of the beetles were caught in the southeastern section of the city, in the vicinity of freight yards. Some 60 percent were caught within a radius of 1½ miles of the Food Terminal and Farmer's Market. All of the infestations discovered last year persisted. One beetle was caught at Lockport for a first record. The catch at Rochester, double that of 1935, was concentrated near the New York Central Railroad yard. Fourteen cities were trapped this year.

Trapping resumed in Vermont after a 3-year lapse revealed a sizeable infestation at Burlington and negative results in three other cities. No beetles were caught in three cities trapped in New Hampshire. Of the 19 cities and towns trapped in the nonregulated area of Maine, only Brewer disclosed an infestation.

There was a 50-percent reduction over last year in the number of beetles caught in Indianapolis, Ind., with only one beetle picked up in the area previously treated. Small initial finds were reported at Fort Wayne and South Bend, Ind. Ten cities were trapped in Indiana in 1936.

From captures of 6 beetles in 1934 and 39 last year, this season's catches in Chicago increased to 3,740 beetles, more or less segregated in 6 rather widely separated infestation centers. Trapping in Chicago this year was much more extensive than in either of the 2 previous years. Some 7,500 traps were systematically distributed in all sections of the city likely to contain infestations. Traps were concentrated in sections showing infestation in 1935 and in sections untrapped last year. As infestations were turned up in sections affording desirable soil conditions for beetle survival, additional traps were concentrated at these points. At the end of this season, a fairly complete picture of the Chicago infestation centers and degrees of infestation was available. A negligible infestation persisted in East St. Louis, Ill. Trapping in five additional Illinois cities was with negative results.

This year 128 beetles were caught in Detroit, Mich., as contrasted with successive years' catches, starting in 1932, of 8, 4, 10, and 23 beetles, respectively. The use of 4,500 traps permitted coverage of practically all sections of the city. Over half of this year's collections were taken in the southwestern sections of the city in the vicinity of the Detroit Railroad produce terminal.

There were six other scattered locations where beetles were caught in numbers, and a scattering of single catches. Dearborn reported a one-beetle first-record infestation. Results in five other Michigan cities were negative.

There was a drastic reduction in the infestation at St. Louis, Mo. Whereas 1,351 beetles were caught in 1934, and 1,232 in 1935, this year's catch was reduced to 88 beetles. Of this total, only 14 came from the extensive area treated in 1934 and 9 of these came from two adjoining blocks in the center of the treated area. This amounts to a 99-percent reduction in beetle population in treated sections. In blocks treated for the first time in 1935, the catches totaled 59 beetles in 4 blocks. This represents a reduction of approximately 85 percent. Most of the 15 remaining beetles were taken in blocks contiguous to previously treated areas. As fast as beetles were trapped this year in unpoisoned sections, lead arsenate was applied. No beetles were caught in traps distributed in five other Missouri communities.

Traps were operated in four Kansas cities this year with negative results. Placement of traps in this State was largely occasioned by the erroneous report of the finding of a Japanese beetle near Manhattan early in May.

Early-season trapping activities in 1937 began with the placement of traps in Miami, Fla., on April 21. Trapping was completed before the end of the fiscal year in Mobile, Ala., in five cities in Florida, in two localities in Georgia, in New Orleans, La., and in two nonregulated communities in South Carolina. At the end of the year traps were in operation in 231 cities and towns in 16 States.

Trap captures recorded during May and June 1937 included 1 beetle at Atlanta, Ga.; 160 beetles at Greensboro; 126 at Winston-Salem; 36 at Spencer; 35 at East Spencer, and small captures at five other communities in North Carolina: 8 at Marietta and 3 at Gallipolis, Ohio; 7 at Charlottesvile, Va.; and 2 at Charleston, S. C. The find at Atlanta, Ga., was a first record; the others were survivals of previously determined infestations. A first-record collection of 750 beetles at the George Washington Birthplace National Monument at Wakefield, Va., was reported on June 19.

SUPPRESSIVE MEASURES

With the extent of the Chicago infestations as well defined as could be accomplished in one season, the Illinois officials were in a position to inaugurate a control program in the city. Approximately 130 acres were sprayed with lead arsenate at the usual dosage of 1,000 pounds per acre. Treatment of 95 acres was accomplished between August 24 and November 16, 1936. Operations were resumed on May 6, 1937, and treating of the remaining 35 acres was accomplished by June 11. Lead arsenate and labor for its application were supplied from a $17,000 State fund. This Bureau furnished a supervisor, two sprayers and operators. Two spray outfits borrowed from the Chicago Park Department were utilized. Illinois State officials and Chicago municipal officials cooperated fully in this control work. In addition the State maintains an intrastate quarantine to restrict the movement of host plants from infested sections. This quarantine was revised effective February 1, 1937, to add the additional infestations disclosed by the 1936 trapping.

At the conclusion of the seasons' trapping in Detroit, Mich., treatment of 118 acres was begun. The Works Progress Administration, State, and city, furnished all items except supervision, which was furnished by this Bureau. Between October 6 and November 6, 1936, lead arsenate was sprayed on 48 acres; the remaining 70 acres were treated between April 6 and May 21, 1937. Soil insecticide application in Detroit extended to all infested sections in the southeastern part of the city, to those blocks in which more than one beetle was found, and to most of the single-beetle finds.

In St. Louis, Mo., 61 acres were treated; 26 of these were in the infestation areas of 1934 and 1935. The dosage was reduced to 500 pounds per acre on two adjoining blocks in the center of an area treated in 1934. In addition, 13 acres in scattered locations in the area sprayed in 1934 were re-treated at normal dosage. As fast as beetles were trapped this year in unpoisoned sections, lead arsenate was applied. The Federal Bureau, the State of Missouri, the city of St. Louis, and the Works Progress Administration cooperated in this program. The Bureau furnished two high-pressure sprayers, one operator, and a general supervisor. The State furnished a foreman to assist in the work and sponsored the W. P. A. project through which the lead arsenate and labor were secured. Incidental supplies were furnished by the city.

Ten tons of State-purchased lead arsenate were applied to 20 acres of newly infested areas at Erie, Pa., between April 29 and May 12, 1937. The project, for which two Federal-owned sprayers were provided, was manned by labor paid from State funds.

Funds for labor and 22 tons of lead arsenate for a soil-treatment program at Cleveland and Marietta, Ohio, were provided by a State appropriation of $32,500. At Cleveland 23 acres were treated between May 17 and June 8, 1937. In Marietta 17 acres were sprayed between April 15 and April 24, 1937. Federal equipment was used.

At Indianapolis, Ind., the treating program began April 22 and was completed May 24, 1937. State-purchased lead arsenate was applied to 21 acres. The Federal Bureau paid for the operators and supervision and supplied two spray outfits.

FEDERAL AND STATE REGULATORY MEASURES

Revised regulations were issued, effective March 1, 1937, to extend the restricted zone. In Ohio, the infested cities of Cleveland, Columbus, Steubenville, and Toledo, all of Columbiana and Mahoning Counties, and scattered townships in Carroll, Jefferson, and Stark Counties were placed under Federal regulation. Brewer, Maine; points in Anne Arundel, Baltimore, and Frederick Counties, Md.; an area in Erie County, N. Y., including Buffalo, Lackawanna, and three surrounding townships; and Burlington, Vt., were included in the restricted zone as isolated areas. Other extensions of the regulated area include districts in Chesterfield and Princess Anne Counties, Va.; also the counties of Hancock, Harrison, Marion, Monongalia, and Taylor, and the city of Parkersburg in Wood County, W. Va.

This revision further required the certification of fruits and vegetables when shipped during the period June 15 to October 15, inclusive, from other portions of the regulated zone to isolated areas at Brewer and Waterville, Maine; Buffalo, N. Y., or to the other regulated parts of Erie County, N. Y.; Cleveland, Columbus, and Toledo, Ohio; Burlington, Vt.; and Parkersburg, W. Va. No restrictions, however, were placed on the movement of any fruits or vegetables from these outlying portions of the regulated area.

An amendment to the regulations, effective May 10, 1937, added to the territory from which the movement by refrigerator car or motortruck of fruits and vegetables is restricted the counties of Kent, Queen Annes, Somerset, and Worcester, most of Caroline County, 1 point in Dorchester County, and 10 districts in Wicomico County, Md.; and also Accomac and Northampton Counties, Va. Under a proviso in this amendment the area designated as heavily infested may be extended or reduced by the Chief of the Bureau when in his judgment such action is considered advisable.

Supplementary intrastate quarantines issued by Ohio and West Virginia placed under regulation the newly federally regulated areas in these States.

Incipient infestations in Georgia, Kentucky, and Tennessee, and in the nonregulated portion of Pennsylvania were not of sufficient importance to justify quarantine action. The situation in North Carolina was adequately handled by continued enforcement of an intrastate quarantine extending to all important isolated infestations in the State. A North Carolina inspector devoted his entire time to enforcement of the State regulations. Chemical treatment of isolated infestations to avoid Federal quarantine action was employed in Illinois, Indiana, Michigan, Missouri, and South Carolina.

HIGHWAY INSPECTION SERVICE

During July, with road movements of quarantined products at a peak, 24 stations were added to those already in operation at the beginning of the fiscal year. Forty roads were posted by August 1, of which number 1 was in Maryland, 5 were in New York, 2 in Ohio, 12 in Pennsylvania, 12 in Virginia, and 8 in West Virginia. At the peak of the work 64 road inspectors were employed.

Closing of the regular stations began late in August, and gradual abandonment of the posts continued during October and November. By the end of November the only remaining station was that on U. S. Route 1, south of Fredericksburg, Va. This station operated 16 hours a day during December. No year-round stations were kept in operation.

Organization of the road-patrol activities in the spring of 1937 began with the posting, during the last 2 weeks in March, of five road stations to handle southbound traffic from the slightly enlarged Virginia regulated zone and two

road stations on the Maryland-Virginia State line. The extension of the regulated area to parts of Ohio made it necessary to establish six new posts on as many highways in that State. Between April 18 and 30, 14 posts were established in Pennsylvania and West Virginia in addition to those in Ohio, most of them with one inspector each, operating 8 hours per day. This concluded the posting of the most important highways.

When the seasonal restrictions on fruits and vegetables became operative on June 15, four additional stations were opened in Virginia. Inspection personnel was increased during June and full quotas of men were assigned to the posts by June 30.

At the end of the fiscal year there were in operation 32 road stations, 2 of which were on the Maryland-West Virginia State line, 6 in Ohio, 11 in Pennsylvania, 9 in Virginia, and 4 in West Virginia. A maximum of 60 inspectors were engaged in road inspection during the spring season.

Trucks returning empty to southern points after driving through sections in which beetles were swarming were again found to contain large numbers of living beetles. A total of 1,492 beetles were taken from 250 trucks. Finds ranging from 20 to 66 beetles were common. Seventy lots of infested plant material were intercepted at the posts, from which were taken 120 adults and 56 grubs.

Counts of all motor vehicles stopped for inspection at the road stations during the year totaled 3,919,286. Uncertified quarantined products were found in 20,355 vehicles.

CERTIFICATION AND TREATMENT OF NURSERY STOCK

Continued beetle population build-up in the metropolitan area of New York City was again responsible for additions to the number of nurseries and greenhouses found to be infested with the Japanese beetle. Few important commercial establishments in this area maintaining classified status under the quarantine regulations remained uninfested by the time the nursery and greenhouse scouts were dismissed late in August. Observations by scouts engaged in the survey of classified premises showed that unfavorable environmental conditions during the winter of 1935–36 caused a heavy grub mortality in the older infested area. This resulted in a decided decrease this summer in the number of Japanese beetles present in the Philadelphia area. The water-front district was practically free from flying beetles, and they were also scarce in parks and public squares nearest the markets. This condition was noted in Camden and Philadelphia suburban areas. In Delaware, sections of southwestern Pennsylvania, north-central New Jersey, and the metropolitan sections of New York City there were heavy concentrations of beetles. Windrows of beetles that had flown to sea and were washed back by the tides were again observed on the ocean beaches of northern New Jersey, Staten Island, and Long Island. There were definite increases in the beetle infestation throughout the bean-growing section of Maryland and the Eastern Shore of Virginia.

Many new infestations were found during 1936 in nursery and greenhouse premises in northern New Jersey and Virginia. A total of 23 nursery and greenhouse establishments were infested in the New England sector. No classified nurseries were found infested in West Virginia or the Eastern Shore of Virginia. The last of the nursery and greenhouse scouts were dismissed on September 19.

There were no new developments in the procedure for the sterilization and fumigation of nursery stock, other than the formal approval of the paradichlorobenzene treatment of certain varieties of azaleas. This type of treatment was also tried with some measure of success on other varieties of plants to determine the effect of the fumigant on survival of the plants.

Owing to the extremely dry weather there was little movement of nursery stock in September. In general, however, shipments were heavier this year. Throughout the regulated area there was an increase in the number of shipments of nursery stock during February over those in the same month for the past several years. Extremely mild weather reported in most sections as early as January stimulated the nursery trade to much above average. Nurseries were able to ship almost continuously throughout the winter.

By March temporary inspectors were required at several points to meet the demands of the increased nursery activities. At Trenton, where 1 nursery reported 13 carload shipments for the month, 6 temporary inspectors were added. Spring shipments of nursery stock were not completed this year until

the end of June. Many greenhouses reported the largest volume of business since 1929.

About 1,000 samples collected from 97.7 acres of nursery plots, heeling-in areas, and frames treated with lead arsenate were analyzed by the Division of Insecticide Investigations to determine the concentration of the poison in the soil. Application of the poison to areas showing dosages less than the required amount was completed by June 30. Initial applications of lead arsenate were made to 10.8 acres of nursery plots and heeling-in sections.

Commercial establishments conforming to the requirements for classification increased from 2,271 to 2,365. Divided on the basis of classification, 1,721 of these establishments were in class I, 624 in class III, and 20 in an intermediary classification. The number of uninfested classified nurseries increased by 85. Many classified establishments dropped their classification upon the finding of an infestation on their premises. There was a net increase of nine in the number of infested classified establishments.

Emergence of adult Japanese beetles was reported as early as May 13 from Holmes, Pa. Adult beetles were also discovered on May 15, at Norwood, Pa.

CERTIFICATION OF FRUITS, VEGETABLES, AND CUT FLOWERS

Demands for the inspection of fruits and vegetables during the 1936 period of adult beetle flight were met by a corps of 138 inspectors. Thirty inspection centers were established throughout the regulated area: One each in Connecticut, the District of Columbia, and Maine; two each in Massachusetts and Pennsylvania; three in Virginia; four each in New Jersey and Maryland; five in Delaware; and seven in New York.

Fumigation of refrigerator cars was required on a larger scale than ever before. For the second season inspection of all southbound fruits and vegetables was concentrated at Fredericksburg, Va. This was for the purpose of eliminating the possibility of reinfestation of certified produce traveling through the flight area. By centralizing this work at Fredericksburg it was possible to reduce the force to the minimum in southern New Jersey, eastern Pennsylvania, and Maryland. An administrative order, effective June 1, 1936, exempted from the quarantine restrictions certain articles that theretofore had required inspection and thus relieved shippers and inspectors of considerable routine work in connection with the certification of noncarriers of the Japanese beetle.

Inspection of freight cars destined to or reconsigned from Chicago, Cincinnati, Kansas City, Milwaukee, and St. Paul netted about 200 live beetles. About 75 percent of them were taken from refrigerator cars of produce from the Eastern Shore. The living beetles probably gained entrance to the cars through hatch screens that were sometimes broken by falling cinders or in connection with reicing. Heavier screens, wired in, were prescribed as soon as this situation came to the Bureau's attention.

The quantity of farm products certified in New Jersey was more than three times as great as in the summer of 1935. Owing to the decrease in the number of beetles and conditions in general at the time, requirements for the fumigation of refrigerator cars for potato shipments and screening of cars were lifted on September 10.

Large quantities of beans offered for inspection in Maryland and Virginia areas necessitated the use of 11 bean machines and 12 additional inspectors.

The seasonal restrictions on fruits and vegetables were removed September 21. The restrictions on the movements of cut flowers continued in effect, however, until October 15.

In the course of the seasonal quarantine on fruits, vegetables, and cut flowers, inspectors removed 2,218 adult beetles from 6,150,311 packages of commodities certified for transportation to uninfested States. The articles from which the greatest numbers of beetles were removed were beans, cut flowers, corn, and potatoes.

CERTIFICATES ISSUED, VIOLATIONS INVESTIGATED, AND PROSECUTIONS TERMINATED

During the year 365,035 certificates of all kinds were required to cover quarantined products moving to nonregulated territory.

Table 6 shows the quarantined articles intended for shipments from the regulated area and for use in certified greenhouses or surface soil plots, in heeling-in areas, or in plunging areas, which were fumigated or sterilized during the 12-month period.

TABLE 6.—*Materials fumigated or sterilized under Japanese beetle quarantine regulations, fiscal year 1937*

Treatment	Plants	Potting soil	Sand		Surface soil	Surface soil with plants	Berries	Potatoes	
	Number	*Cubic yards*	*Cars*	*Cubic yards*	*Square feet*	*Square feet*	*Crates*	*Cars*	*Bushels*
Lead arsenate	103,488				136,330	1,232,146			
Carbon disulphide gas or emulsion	7,314	2,850	76	1,224	54,167		6,032		
Naphthalene		81			53,434				
Steam		561							
Hydrocyanic acid								630	609
Paradichlorobenzene	50,732								

	Tomatoes		Peppers		Onions	Egg plant	Empty cars	Mixed shipments	
	Cars	*Baskets*	*Cars*	*Bushels*	*Cars*	*Bushels*	*Number*	*Cars*	*Bushels*
Hydrocyanic acid	4	3,441	3	3,923	31	1,119	7,452	32	298

Nursery and ornamental stock, sand, soil, earth, peat, compost, and manure were certified for shipment from the regulated areas during the year in the following quantities:

Plants	number	47,565,188
Sand, earth, and clay	carloads	7,931
Peat	do	7
Manure and compost	do	109

Fruits, vegetables, moss, and cut flowers certified during the seasonal quarantine on these articles were as follows:

Fruits and vegetables	packages	6,101,010
Moss	bales	6
Cut flowers	packages	49,301

A total of 1,810 apparent violations of the Japanese beetle regulations were investigated by the Bureau. Convictions were secured for two violations; one a trucker transporting string beans from Norfolk, Va., to Morristown, Tenn.; the other a floral company which shipped palms and ivy plants from New York, N. Y., to Miami, Fla.

COOPERATIVE ENTERPRISES

Funds partially or wholly covering the cost of labor and equipment for the trapping programs within their respective States were contributed by Georgia, Illinois, Indiana, Kansas, Maine, Missouri, New York, North Carolina, Ohio, Pennsylvania, and West Virginia. The city of St. Louis, Mo., also contributed funds for the trapping program. Labor for the program was provided in St. Louis, Mo., and in Detroit, Mich., by the W. P. A. The National Youth Administration provided the manpower for the trapping program at Erie, Pa. The total contributions from Federal welfare, State, and city agencies for labor and materials used to set and remove traps were approximately $34,000. Cooperative control or quarantine activities in the regulated areas again received State funds from Connecticut, Delaware, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, Rhode Island, and Virginia.

Bureau cooperation in the experiments to determine the effectiveness of the nematode *Neoaplectana glaseri* in eradicating established infestations of the Japanese beetle is being continued at the State laboratory at White Horse under the agreement reached last year with the New Jersey Department of Agriculture.

PHONY PEACH DISEASE CONTROL

Under the expanded program of inspection conducted cooperatively with the plant-pest control officials of the States concerned, and augmented by allotments from the emergency relief appropriations, intensive inspection for the phony peach disease was made during the 1936 field season in the 11 known infected States, and a survey was conducted in 9 other peach-producing States. Approximately

150 Federal and 50 State inspectors were employed. This work, carried on in more than 550 counties, covered the region from Texas, Oklahoma, and Missouri, east to the Atlantic, south to the Gulf, and north to Pennsylvania and New Jersey. This activity has, it is believed, rather accurately delineated the infected localities in the eastern part of the United States. The disease was found for the first time in Pennsylvania and Indiana, in one county each. Nursery areas were given first attention, as heretofore; the number of nurseries receiving environs inspection was more than twice that of any previous year. Of the 425 nurseries inspected in the infected States, 104 were found exposed, and the diseased trees on neighboring properties were promptly removed from the vicinity of all nurseries except one. Mandatory orders have now been issued by several States requiring the prompt removal of any trees infected with the phony peach disease.

Nearly 13,000,000 peach trees in commercial plantings and home orchards were inspected; 140,844 trees infected with the disease have been removed from 6,633 properties. To protect accomplishments to date, follow-up inspection on all known diseased properties is under way in the 1937 field season.

The emergency relief project begun in 1935 was continued and has accomplished the removal of over 64,000,000 diseased, abandoned, and escaped peach trees from 11 infected States. The project was reduced 65 percent at the close of the fiscal year, having nearly accomplished its purpose in five States.

Control work has progressed to the point where the disease is being pushed back from the outer rim toward the center of infection and the intensity reduced at the center. Affected States are cooperating by furnishing men or funds, or both, and standardized State quarantines are in effect which provide for shipping only stock produced in disease-free environs.

Field headquarters for the project were moved in March 1937 from Atlanta, Ga., to Little Rock, Ark.

CONTROL OF PEACH MOSAIC DISEASE

Activities of the Department to eradicate the virus disease of peach trees known as peach mosaic have resulted, since the project was started as a cooperative Federal-State activity in 1935, in materially reducing the intensity of infection in many of the affected commercial peach-growing areas. The results of the program in Colorado and Utah are particularly significant. In Utah all known infected trees have been removed. In Colorado approximately 3,000 infected trees were found and destroyed during the 1937 spring inspection. This is less than one-third the number found last year, and approximately one-ninth that of the previous year. This marked reduction of the disease in this area, which appears to be approaching commercial control, has restored the confidence of the peach growers of the State, as indicated by their carrying on an extensive replanting program.

Control work was also carried on during the year in Arizona, California, New Mexico, and Texas. Extensive surveys were conducted in the six infected States, as well as all States bordering thereon, with the result that the disease was found for the first time in Oklahoma. One diseased tree, which had been shipped from an infected area, was found in Indiana, but no local spread was reported.

Since the control program was started in 1935, approximately 36,000 diseased trees have been removed and over 6,750,000 trees have been inspected. During the year 27,486 infected trees were removed and nearly 3,600,000 trees were inspected for the disease. This work has been carried on under allotments from emergency relief appropriation acts in close cooperation with plant-pest control officials of the affected States.

A public hearing to consider the advisability of establishing a Federal quarantine, held August 19, 1936, resulted in the decision that, for the present at least, State regulatory action would suffice to prevent the spread of peach mosaic. Uniform State quarantines are in effect.

CITRUS CANKER ERADICATION

The campaign of eradication of the citrus canker disease conducted throughout the citrus-growing areas of Texas and Louisiana, which was expanded and stimulated in 1935 and 1936 by allotments from the emergency relief appropriations supplementing regular appropriations, and by State funds, was continued on a similar intensive scale in 1937. In the 2-year period since the relief allotments have been made available, 58 counties and parishes in these 2

States have been inspected, many of them repeatedly, and it is believed that all infected areas have been located. Citrus canker was found in August 1936 on 3 properties in Texas not heretofore known to be infected, and 2 in Louisiana in the fiscal year, as compared with 9 new cases in these States in 1936 and 45 in 1935. These recent findings were on old infection areas, with the exception of one which was located on an uninhabited island in a Louisiana marsh. This island was inaccessible by boat, and the canker would no doubt have existed indefinitely except for the autogiro survey which was conducted in the Louisiana-Texas area in the spring of 1936. Recurring infections found in the Texas counties of Galveston, Brazoria, and Harris in the winter of 1936–37 were promptly removed. These involved several hundred young seedlings on properties from which diseased trees were eradicated during the past 2 years. No canker could be found on repeated inspections in the Beaumont, Tex., areas where an old infection center was located in the winter of 1935–36. No canker could be found in Texas south of the Galveston-Brazoria area.

Owing to the existence of citrus canker in Alabama and Mississippi in former years, and because of a heavy growth of wild and abandoned *Citrus trifoliata* trees in these States, a thorough survey was made in Mississippi during the year, and is under way in Alabama and that part of western Florida adjacent to the Alabama border. No citrus canker has been found in any of these States as a result of this survey.

The year's work has represented the inspection of 59,000 properties in 61 counties in 5 States.

Millions of escaped *Citrus trifoliata* growing in dense junglelike swamps and woodlands, or in abandoned nurseries, have been destroyed in the noncommercial areas of these five States, thus removing the medium through which citrus canker might eventually reach the commercial areas. Such eradication has been accomplished on a very large proportion of all citrus-growing properties in the infected areas of Texas and Louisiana. Since the beginning of the project in August 1935 nearly 21,000,000 such trees have been destroyed by relief labor, representing approximately 45 man-years of employment.

INSECTS AFFECTING FOREST AND SHADE TREES

ADVICE AND COOPERATION IN THE CONTROL OF FOREST INSECTS

Federal and State agencies administering forest lands, and private timber owners, look to the Bureau for information on the status of forest-insect infestations and for advice regarding the need of control and the methods to be used. As in past years, much time and effort of the Division of Forest Insect Investigations have been devoted to making surveys to locate and define areas where infestations occur, and preparing recommendations for control, including plans for work and estimates of the cost. These activities are of a service nature and are carried out in close cooperation with Federal organizations administering timbered lands, such as the Forest Service, National Park Service, and Bureau of Indian Affairs, and through them with the C. C. C. Similar cooperation also extended to State agencies and in some cases to private timber owners or associations. The land-managing units are responsible for administering and carrying out the control operations, although in most cases the technical direction and leadership of the work are supplied by the Bureau.

Most of this work has been concerned with various tree-killing bark beetles and has been carried out in the forested areas of the West from the field laboratories at Fort Collins, Colo., Coeur d'Alene, Idaho, Portland, Oreg., and Berkeley, Calif. In these cooperative activities more than 6,000,000 acres of forest was examined last year for bark beetle infestation. In addition to numerous recommendations made verbally or by letter, 83 reports presenting data and recommendations as to the status and need for control on forested areas were prepared and submitted to land-managing units. Fifty-one, or about two-thirds, of these reports were submitted to the Forest Service, 11 to the Park Service, 1 to the Indian Service, and 20 to private owners or organizations. These special reports dealt with the status of insects and involved consideration of a wide variety of conditions, and not all of them recommended that control work be undertaken. Following recommendations included in the reports, the land-managing units carried out recommended control work on approximately 750,000 acres.

For the first time in many years the eastern spruce beetle reached outbreak proportions in several areas in New England and New York. On the recommendation of the Bureau the land-managing agencies have work under way to control this outbreak on some 22,000 acres in the Green Mountain National Forest and adjacent privately owned lands.

On the advice and under the technical supervision of the Bureau, the Forest Service is continuing the effort to control the outbreak of the forest tent caterpillar in recreational areas in the Lake States.

RESEARCH ACTIVITIES

EFFECTS OF CLIMATE ON BARK BEETLES

Following the purchase of new low-temperature equipment at three of our western stations, the laboratory study of the effects of extreme cold upon the brood of pine bark beetles was considerably expanded. Pertinent facts so far established may be stated as follows: (1) Of the three most destructive western bark beetles the brood of the western pine beetle is least resistant to low temperatures, that of the Black Hills beetle is most resistant, while that of the mountain pine beetle is intermediate. (2) A species occurring in warmer parts of its range is less resistant to low temperatures than the same species in colder areas. (3) Bark beetle brood is less resistant to unseasonably low temperatures in the fall and early in the spring than to similar temperatures during the dead of winter, because of an establishment of "cold hardiness." (4) There are strong indications that individuals of the same species of bark beetle reared in the same area vary considerably as regards resistance to low temperatures according to the host tree in which they occur. (5) Some work upon the relation of the water and the lipoid contents of the body to cold hardiness has been begun but has not yet reached definite conclusions.

Something of the relation of drought periods and outbreaks of the western pine beetle has been known for some time. The frequency of drought periods in the Pacific Northwest has been studied through an analysis of tree rings and growth fluctuations covering the last 650 years.

PENETRATING OIL FOR CONTROL OF BARK BEETLES

For several years experiments with the use of penetrating oils in the control of bark beetles in sugar pine and ponderosa pine were conducted in California with more or less erratic results due to the thickness of the bark in these trees. However, the results were so excellent, where penetration was obtained, that it was decided to move these experiments to Coeur d'Alene and try the method out on bark beetles in the thinner barked lodgepole pine. The use of this method permits control work to proceed during seasons of high fire hazard. Definite progress has been made, but considerable experimental work is still needed to determine what factors, such as temperature, moisture content of bark, etc., are conducive to success.

INJECTION OF CHEMICALS INTO TREES

Experiments with the introduction of chemicals into the sap stream of trees was begun as a promising method of controlling bark beetles. The early work was done largely at Asheville, N. C. It has been applied on a fairly large scale in several experimental control operations in the northern Rocky Mountains and has proved very successful in trees which have not been infested so long that the water conduction has been seriously affected by the development of the blue stain fungus.

Living trees can also be injected with copper sulphate or other preservatives, which kill the tree and prevent later insect attack. Such material can then be used in rustic work or otherwise without injury from insect attack. Tree injection has been put to another use in the eradication campaign against the Dutch elm disease, where a modification of the method is used to kill elm trees and render them unsuitable for the attack and development of bark beetles which act as vectors of the disease organism.

WHITE GRUBS IN NURSERIES AND PLANTATIONS

Further investigations upon methods of treating the soil in forest nurseries so as to prevent later infestation have shown that all methods thus far tried

have either not prevented infestation or have been destructive to the seedlings as well. Poisoning the foliage of nearby host plants in order to kill the adult insects does not appreciably decrease the leaf chafer population. However, many tests indicate strongly that heavy populations of grubs may be adequately controlled by proper applications of carbon disulphide to the infested soil.

In the case of plantations, observations over several years have proved that a heavy population of white grubs in the sod prevents the successful establishment of a plantation. This can best be determined by actual sampling of the proposed plantation site. Losses in plantations can be reduced by avoiding areas that are heavily infested or by using wide deep furrows in which to plant in such areas. Indications are strong that grub abundance in a given area is controlled by the presence of suitable host trees and shrubs for the adult beetles. It is believed, therefore, that white grub populations in nurseries can be reduced by avoiding the use of these more favored host plants as hedges or ornamental plantings around such nurseries and by destroying as much as possible of such material as occurs naturally in or near the nurseries.

INSECTS AND THE DUTCH ELM DISEASE

Work upon insect carriers of the Dutch elm disease was continued both at Morristown, N. J., and at Oxford, England. The work at Morristown had previously established beyond doubt that the smaller European elm bark beetle is a frequent vector, but it is also now known that the native elm bark beetle can and does perform the same function. In the former case the young beetles' habit of feeding in the crotches of twigs makes it an effective vector. In the case of the native elm bark beetle the young adults emerging in the fall often bore into the bark of living elm trees and there pass the winter. Their burrows are often extended entirely through the bark to the xylem, and if such beetles are contaminated with the fungus, the disease often develops and kills the tree. In infected areas such as those in Cleveland, Ohio, and Indianapolis, Ind., where no European elm bark beetles are known to occur, the native beetle is almost certainly the vector.

During the year more than 10,000 insects were collected from felled elm trees put down at various points in the badly infected area of New Jersey. These insects were carefully collected in individual capsules and later cultured for the presence of the Dutch elm disease fungus. Many species of insects were collected, but of these only six were contaminated with the disease. These are *Scolytus multistriatus* Marsh., *Hylurgopinus rufipes* Eichh., *Magdalis armicollis* Say, *Xylosandrus germanus* Bldfd., *Xylobiops basilare* Say, and *Conotrachelus analglypticus* Say. Of these only the first two showed contamination in any significant percentage of the numbers cultured.

PINE SCALE INSECTS

Both in the West and in several points in the East a blighted condition of the twigs of several species of pines has been found associated with infestations of different species of *Matsucoccus*. In the Prescott National Forest and at other localities in the Southwest the association of these scales with the Prescott twig blight has been so close as to suggest that the scale insect may be an important factor. An intensive study, both on the Prescott form and on an eastern species affecting pitch pine, has been begun and will be continued on Emergency Conservation Work funds.

SPRAYING EXPERIMENTS

Considerable progress was made in developing concentrated mixtures of many of the well known insecticides used in insect control. These concentrated mixtures adhere better, and a greater deposit is obtained per unit area of leaf surface than with the conventional spray mixtures. Only from 1 to 10 gallons of the concentrated mixture is required per acre as compared with 400 to 700 gallons of the ordinary mixture. This is such a great saving in weight that it can be used in spraying from the air and the costs still kept lower than with ground spraying. In cooperation with other agencies, concentrated mixtures of certain insecticides were applied from an autogiro in experiments to control heavy mixed infestations of the spring cankerworm and fall cankerworm at Morristown, N. J., and for the gypsy moth at Freetown, Mass. In these tests

the method of application proved to be quicker and cheaper than ordinary ground spraying, and certain of the materials tested were more effective than when the same chemicals were applied by the old methods.

GYPSY MOTH AND BROWN-TAIL MOTH CONTROL

Gypsy moth and brown-tail moth suppression and control work has been continued throughout the year. The regular funds have been supplemented by allotments from the Works Progress Administration amounting to $2,026,000 for gypsy moth work in Vermont, Massachusetts, Connecticut, New York, New Jersey, and Pennsylvania, and $477,699 for work on the brown-tail moth in the New England States. These funds have been expended under the regulations of the W. P. A. and 96 percent of the men employed were taken from relief rolls. The number of men on these projects throughout the year averaged 2,492 on the gypsy moth project and 1,034 on the brown-tail moth project.

The work on the gypsy moth project was rather continuous throughout the year, whereas on the brown-tail moth project only a few men were employed until late in the fall, after which the force was maintained at a maximum throughout the winter. Cooperation with the States concerned in carrying on the work and in furnishing supervision in some of the territory has been continued much the same as during the previous year and this has made possible the coverage of a much greater portion of the territory where work is needed than would otherwise have been the case.

Work was continued in Vermont, Massachusetts, and Connecticut by men detailed from C. C. C. camps, principally between the barrier zone and the Connecticut River. It was directed from the office of the Bureau at Greenfield, Mass. Additional work was carried on from C. C. C. camps by the State conservation department in New York. All of this work was planned so as to avoid duplication of effort by the Federal, State, and local agencies who were engaged in gypsy moth and brown-tail moth control.

In cooperation with the Division of Control Investigations of the Bureau, improvements have been made on various types of machinery and equipment used in field work. Among these was the development and adaptation of a machine for reducing brush and slash to sawdust and fine shavings in order to eliminate the fire hazard of burning such material after clean-up work had been done.

On account of the finding of gypsy moth colonies in areas remote from a water supply, spraying machines capable of developing 1,500 pounds' working pressure with suitable hose and fittings needed for this purpose have been secured, and this has made possible the spraying of areas in some cases as much as 12,000 feet from the point where the sprayer is set up at the water supply.

Special attention has been paid in removing tree growth in forest areas to see that the species not favored by the gypsy moth or only partially favored are given preference when this work is done, and an attempt has been made to encourage sprout growth of resistant species that developed following general thinning operations. In limited areas the growth is such that permanent protection from gypsy moth is possible by following these methods, but in sections where favored growth predominates intensive treatment work is necessary. This is particularly true in the territory where the bulk of the gypsy moth work is being carried on, as the extermination of the insect or its immediate reduction to such numbers as to prevent spread to other parts of the United States is the main purpose of this project. Other improvements in methods and equipment designed to reduce the cost of operation are being developed on this project.

Weather conditions during the winter, considering the territory as a whole, were favorable for this type of work. The snowfall was below normal and the temperatures were not excessively low. This made possible the examination of an unusually large acreage and the clean-up of many infestations which it would have been impossible to reach had inclement weather and deep snow impeded the progress of the work. The mild weather in many sections reduced the normal gypsy moth mortality in the egg stage, and owing to the absence of late frosts or continuous rain during the hatching season the larvae in many areas suffered little mortality from natural causes. During the month of June, when the bulk of the spraying work is carried on for gypsy moth control, weather conditions were less favorable for the work than at any time for many

years. This seriously interrupted this type of work and resulted in a great reduction in the acreage that normally would have been sprayed with the equipment available.

GYPSY MOTH PROJECT

Owing to the finding of 12 small gypsy moth infestations in Washington County, Maine, prior to the close of the last fiscal year a limited amount of work was continued in that county during the summer and fall. Egg clusters were found and treated in four towns, and the territory in and surrounding each colony was thoroughly cleaned. Four small infestations were located on residential property in the city of Calais and these were thoroughly treated. This work concluded the plan for the gypsy moth W. P. A. project in Maine.

While this work was being carried on, inspectors from the Entomological Branch of the Department of Agriculture in Canada examined territory on the east side of the St. Croix River, Charlotte County, New Brunswick. The gypsy moth has been found in small numbers on 15 properties in that county. Eight of these were in St. Stephen, the largest infestation being 12 egg clusters; 3 in Milltown, the largest infestation being 8 egg clusters; and 4 were small infestations in adjoining territory.

In New Hampshire the special scouting work in 26 towns and grants in Coos County was finished in July 1936, and no infestation was discovered. A small amount of work was done along the Connecticut River from Lancaster south to the Massachusetts line, and after this was finished the work in New Hampshire was discontinued.

Practically all of the W. P. A. work in Massachusetts and Connecticut was carried on west of the Connecticut River. In Vermont considerable infestation was found from Barnet south to the Massachusetts line but this decreased toward the barrier zone. No infestation was discovered north of Barnet or within the barrier zone area, and the isolated infestations located in Essex, Chittenden County, and Derby, Orleans County, during 1936 were examined but no trace of the insect was found.

In the Massachusetts portion of the zone, conditions are more satisfactory than for many years, but there is much infestation in certain localities between the barrier zone and the Connecticut River that seriously threatens work in the zone. This is particularly true in Deerfield, Northampton, and Russell, where sizeable areas were defoliated by the gypsy moth this summer.

The scarcity of relief labor available for this project in the Connecticut barrier-zone area has limited the amount of work that could be done there, particularly in Litchfield County and in the northern half of Fairfield County. Conditions in the Connecticut zone area are therefore not so satisfactory as in Vermont and Massachusetts. Except in the town of Granby, where heavy feeding occurred this year, infestation between the barrier zone and the Connecticut River is not so heavy as in the other two States mentioned.

In New York intensive scouting was done by W. P. A. forces in Washington, Rensselaer, Dutchess, and Putnam Counties within the zone area and in Albany, Westchester, and Putnam Counties to the west and south of the zone. No infestation was discovered as a result of this work, but in Putnam Valley, Putnam County, and in Shawangunk, Ulster County, sizeable infestations were found. The infestation in Shawangunk was located by employees of the New York Conservation Department after male moths had been taken at one of the assembling cages put out in that locality. The Putnam County infestation was discovered by men from the Civilian Conservation Corps scouting a section of that town. W. P. A. forces assisted in the intensive follow-up work, including selective thinning of favored food species and spraying at each of these infested sites, and in both localities a material reduction in infestation has been noted. Special survey work started in the territory west of the Hudson River in 1936, was completed February 28, 1937. From July 1, 1936, to February 28, 1937, 488 towns and boroughs located in 31 counties were covered but no infestation was found.

State and C. C. C. camp forces supervised by the New York Conservation Department located and treated several small isolated infestations in Columbia and Dutchess Counties within the barrier zone and in Westchester County, the Borough of the Bronx, and Nassau County to the south of the zone. Except for the infestations in Shawangunk and Putnam Valley above referred to, conditions are better in the State of New York than for several years.

This is especially true in the Bronx and on Long Island, where intensive exterminative measures have materially reduced infestation existing there.

In the section of Nassau County under State regulation on account of the gypsy moth, 1,803 shipments of nursery stock, wood products, etc., were inspected and certified as free from this insect during the year.

The small force of W. P. A. workers employed in New Jersey performed intensive scouting work in selected areas in Essex, Morris, Passaic, Somerset, and Union Counties. Much of this work was done in the township of Mendham, Morris County, where a male gypsy moth was taken at an assembling cage during the summer of 1936. No infestation has been found here during the year.

In Pennsylvania scouting work has been done in Lackawanna, Luzerne, Carbon, Monroe, Pike, Susquehanna, and Wayne Counties. Wherever infestations have been discovered intensive follow-up work has been done. The lowlands along the Lackawanna and Susquehanna Rivers were scouted during the summer and fall when water in these rivers was low. On account of the serious flood conditions in March 1936 the lowlands bordering the Lackawanna River from Scranton to its confluence with the Susquehanna River near Pittston and the Susquehanna River from the Ransom town line to the highway bridge at Nanticoke were examined, and this work was extended as far south as Sunbury. Six infestations were found. They were all within 10 miles of Pittston and well within the area of known infestation. Although the river was examined for about 100 miles on both sides, no evidence was found that the gypsy moth had been spread by the flood. Small isolated infestations outside of the State quarantined area were found in the townships of Clinton, Dyberry, and Lake in Wayne County, Clifton in Lackawanna County, and Chestnut Hill in Monroe County. The township of Clifton in Lackawanna County was included in the State quarantine effective July 1, 1937, but as the infestations discovered in the other towns were not considered difficult to eradicate or dangerous from the quarantine standpoint, the four other towns referred to were not included in the new State quarantine. No egg clusters were found at sites of infestations discovered in 1936 in the townships of South Canaan and Sterling in Wayne County, Greene in Pike County, and Lehigh in Carbon County, and it is believed that the infestations have been exterminated. A total of 80,198 shipments were inspected and certified before movement was permitted within or to points outside of the State quarantined area. In making these inspections 321 egg clusters and 665 larvae were located and destroyed. In spite of the numerous difficulties experienced since work in Pennsylvania was started, excellent progress has been made and the situation looks more hopeful each year.

GYPSY MOTH WORK BY CIVILIAN CONSERVATION CORPS CAMPS

C. C. C. camps have continued to work on gypsy moth control under the supervision of the Bureau. Their activities give protection to the gypsy moth barrier zone and reduce the danger of a westward spread of this insect.

Throughout the year 282,497 6-hour man-days were used on this gypsy moth work. This is a reduction of approximately 15 percent of the man-days available during the previous year. At the end of the year, however, there was a decrease in the men available of approximately 50 percent, which indicates a very serious reduction in the volume of work that can be done during the coming year. At the beginning of the year 1,465 juniors and 15 veterans were assigned to this work, but at the end of June 1937 only 733 juniors and 14 veterans were available for it. With this reduction the supervision was reduced from 118 foremen at the beginning of the year to only 65 at the end of the year. Some men were available at the end of the year from 20 different camps in New England, the number ranging from 5 to as high as 120 men in three camps in Massachusetts where the entire project is gypsy moth work.

During the year gypsy moth work by the C. C. C. was discontinued in New Hampshire. Decrease in personel available for this project and regulations of the Emergency Conservation Work resulted in the work in this State becoming isolated from the rest of the C. C. C. gypsy moth project, and its continuance was not warranted as a part of a program to protect the barrier zone. In Vermont the abandonment of camps has resulted in leaving unprotected several areas where serious infestation exists. The same situation

to a lesser extent exists in Massachusetts, and a severe reduction in the number of men allowed for gypsy moth work in Connecticut is resulting in leaving areas unprotected where work should be done. The 20 camps now engaged in these activities are distributed as follows: 5 in Vermont, 9 in Massachusetts, and 6 in Connecticut. All of these camps are under the jurisdiction of the Forest Service of the United States Department of Agriculture except one, which is under the United States Department of the Interior.

During the year work was done in 148 towns, and gypsy moth infestations were discovered in 105 of them, involving a total of 1,162 colonies. The records in table 7 which refer to burlap applied and larvae and pupae destroyed beneath them represent the sum total for the fiscal year. Inasmuch as caterpillars and pupae are found underneath the burlap during July it does not represent the work for the entire season.

The Forest Service has cooperated in the C. C. C. gypsy moth work during the year and furnished the services of an Emergency Conservation Work forester to assist gypsy moth foremen in combining gypsy moth cutting work with silvicultural practices.

The work has resulted in giving added protection to the barrier zone and in reducing the danger of westward spread. In many places favorable for gypsy moth increase and in locations where danger of westward spread is great, conditions have been greatly improved, and those areas where the work has been done are in a much better condition.

Table 7 summarizes the work performed by the W. P. A. and C. C. C. personnel.

TABLE 7.—*Gypsy moth control work, fiscal year 1937*

State	Project	Scouting							Thinning		Fencing		Banding			Spraying		
		Open country scouted					Woodland scouted	Egg clusters creosoted	Woodland thinned	Trees cut in open	Wire erected	Wire removed	Burlap bands applied	Pupae crushed	Larvae crushed	Woodland sprayed	Residential properties sprayed	Trees in open sprayed
		Open areas	Road	Apple trees	Oak trees	Shade trees												
		Acres	*Miles*	*Number*	*Number*	*Number*	*Acres*	*Number*	*Acres*	*Number*	*Feet*	*Feet*	*Number*	*Number*	*Number*	*Acres*	*Number*	*Number*
Maine	W. P. A.	89,323	1,445	129,298	8,064	59,425	820	67	3	217	0	0	0	0	0	0	0	0
New Hampshire	do	34,265	324	6,608	11	47,525	0	126	0	0	0	99,979	4,411	7,740	151,622	0	0	0
	C. C. C.	5,410	65	4,760	2,372	8,044	18,338	209,287	441	317	0	0	0	72,440	335,294	0	0	0
Vermont	W. P. A.	793,380	4,057	670,222	77,392	1,963,263	429,071	46,791	239	2,583	76,698	271,150	130,267	7,175	53,529	241	0	910
	C. C. C.	150,485	930	83,828	8,462	182,609	290,362	124,266	818	1,137	0	0	458,162	51,247	1,416,074	0	0	0
Massachusetts	W. P. A.	97,743	820	116,498	17,135	143,145	183,385	1,724,734	2,905	1,441	323,424	90,263	126,344	636,206	203,010	1,814	3	0
	C. C. C.	51,495	691	190,483	66,886	102,505	199,383	5,501,015	2,386	1,590	0	0	889,789	2,831,164	12,331,780	0	0	0
Connecticut	W. P. A.	137,016	1,998	402,695	235,389	509,267	183,408	51,405	1,000	0	55,895	25,410	49,011	21,015	68,116	2,056	1	532
	C. C. C.	118,545	1,154	293,824	83,378	410,560	199,995	80,227	948	1,387	0	0	529,301	23,464	204,368	0	0	0
New York City	W. P. A.	70,778	558	136,292	152,690	1,003,581	86,526	26,757	299	298	0	0	15,491	0	101,505	23	0	0
New York State	C. C. C.	264,058	1,479	606,329	0	4,921,537	139,152	76,176	345	0	0	0	189,032	0	211,851	2,616	0	49,022
New Jersey	W. P. A.	8,279	80	26,813	2,696	99,876	8,287	0	58	0	0	0	2,445	0	0	0	0	0
Pennsylvania	do	268,646	1,969	543,533	171,467	1,583,047	424,753	367,851	3,005	88	130,668	177,691	716,530	16,369	54,657	9,081	5,762	63,798
Total	W. P. A.	1,499,430	11,251	2,031,959	664,844	5,409,129	1,316,250	2,217,731	7,509	4,627	586,685	664,493	1,044,529	688,505	632,739	13,215	5,766	65,230
	C. C. C.	619,993	4,319	1,179,224	161,098	5,625,255	847,230	5,990,971	4,938	4,431	0	0	2,066,284	2,978,615	14,499,367	2,616	0	49,022
Grand total		2,119,423	15,570	3,211,183	825,942	11,034,384	2,163,480	8,208,702	12,447	9,058	586,685	664,493	3,110,813	3,667,120	15,132,106	15,831	5,766	114,252

CONDITION OF GYPSY MOTH INFESTATION IN NEW ENGLAND

Defoliation caused by the gypsy moth in the summer of 1936 was less extensive for the infested area as a whole than it was the previous year. The total reported area showing from slight to complete defoliation was 428,622 acres, a reduction of 112,147 acres from the total of 1935. With the exception of Massachusetts all of the New England States showed less defoliation in 1936 than the year before. This was particularly true with respect to New Hampshire, where the decrease was very marked. In contrast to the other States there was in Massachusetts a decided increase in areas of defoliation in a few of the eastern counties. This was particularly true in Bristol and Norfolk. No noticeable defoliation was recorded from either Vermont or Connecticut, and in Rhode Island there was a marked decrease. In numerous portions of the infested area, particularly in Massachusetts, it was indicated that the infestation was much more widespread than usual with the possibilities that unless there was heavy winter mortality of egg clusters there would be an increase in defoliation in the summer of 1937.

BROWN-TAIL MOTH PROJECT

The brown-tail moth project was conducted under a W. P. A. allotment of funds in all of the New England States. As in the previous year, it was organized in close cooperation with the States concerned. In Maine and New Hampshire the work was under direct supervision of State officers and in Massachusetts field officers of the State had direct supervision in their respective districts. Men engaged in the work were drawn from unemployed lists through the United States Employment Service and from W. P. A. rolls and at least 95 percent were from relief rolls.

The plan under which the work was conducted called for the examination of all towns within the infested area and a number of others immediately outside for the purpose of determining possible spread and, in addition, the removal of neglected favored food plants, including apple, wild cherry, and plum from selected areas where infestations had persisted.

In the early part of the year the number of men employed was small, but increases in personnel were made rapidly, the maximum number being on the rolls in February, when 1,360 were employed.

During the fall, prior to the shedding of deciduous foliage, all crews were engaged in eliminating favored food plants, and this type of work was performed again from the end of April until the year closed. During the progress of the work 48,867 miles of roadside were examined, which involved the covering of an estimated 4,400,000 acres; 264,468 trees were cut and burned, a majority of these being worthless apple trees; 24,539,091 trees were examined; and 3,046,530 winter webs of the brown-tail moth were removed and destroyed. The State-by-State tabulation of work accomplished is shown in table 8.

TABLE 8.—*Summary of work accomplished under Works Progress Administration brown-tail moth project, fiscal year 1937*

State	Trees cut	Roadside scouted	Estimated area scouted	Trees examined	Brown-tail webs cut
	Number	*Miles*	*Acres*	*Number*	*Number*
Maine	85,017	15,104	1,359,360	6,340,168	743,601
New Hampshire	88,742	12,903	1,161,270	6,094,643	1,523,478
Vermont	22,431	5,212	470,080	6,486,479	3
Massachusetts	68,278	12,266	1,103,940	5,006,534	779,404
Rhode Island	0	993	89,370	210,225	44
Connecticut	0	2,389	215,980	401,042	0
Total	264,468	48,867	4,400,000	24,539,091	3,046,530

Observations made during the summer of 1936 showed practically no defoliation by the brown-tail moth. In a few localities in the extreme eastern part of Massachusetts there was some noticeable feeding. As a result of the work of 2 years conducted under allotment of W. P. A. funds, infestations have been decreased throughout the infested area.

The examination of towns along the western border of the infested area indicates that the insect is not spreading westward and that the clean-up of towns along this border has been effective in reducing the infested territory.

This project was closed June 30, 1937.

GYPSY MOTH AND BROWN-TAIL MOTH QUARANTINE ENFORCEMENT

CERTIFICATION OF QUARANTINED PRODUCTS

Enforcement of the gypsy moth quarantine regulations continued as heretofore, with 21 district inspectors assigned to as many districts. There was a complete shift in the territories assigned to each inspector, so that the men might obtain experience in new sections and in a variety of quarantine activity.

There were no developments requiring revision of existing quarantine regulations. In an administrative order issued March 2, 1937, a few items were added to the list of articles exempted from the regulations as noncarriers of moth infestation.

Twenty-three temporary inspectors were employed in the inspection of Christmas trees and other evergreen material used for Christmas decorations. During the 1936 season only one gypsy moth egg cluster was found on Christmas trees presented for inspection and certification. The discovery was made on a balsam fir at a nursery in southern Vermont. An 8.5-percent increase was noted in the number of Christmas trees inspected and certified for shipment from the lightly infested gypsy moth area. In Maine approximately 51,000 more trees were inspected and certified this year than in 1935. All but 5 percent were balsam firs, the demand for which has been increasing yearly. In Vermont, where approximately 75 percent of all evergreens are spruces, the demand for balsam fir exceeded the supply. Inspection of spruce boughs extended from the middle of October to early in December in Massachusetts and southern Vermont.

New England experienced the heaviest fall demand for nursery stock in several seasons. During October and part of November the assignment of additional inspectors was required in practically all the infested States. Scouting of nurseries that shipped under joint Japanese beetle and gypsy moth certificates was completed in November. No gypsy moth egg clusters were found in or in the vicinity of any such nurseries.

Throughout the year inspectors destroyed 1,257 egg clusters, 235 larvae, and 136 pupae, all taken from material destined to nonregulated points. Inspection of a 12-car shipment of lumber in November netted 125 egg clusters.

Tables 9 and 10 give summaries of the quantities of articles of the respective quarantined products certified during the year.

VIOLATIONS

Apparent violations of the gypsy moth and brown-tail moth quarantine investigated during the year numbered 696. One violation involving a host shipment of uncertified forest products from Stonington, Conn., to Greenport, N. Y., was successfully prosecuted.

TABLE 9.—*Nursery stocks certified under gypsy moth quarantine, fiscal year 1937* [1]

Material	Quantity	Certificates issued	Material	Quantity	Certificates issued
	Number	*Number*		*Number*	*Number*
Shrubs	1,110,066	5,351	Potted greenhouse plants	8,042	310
Specimen trees	24,362	1,161	White pine trees	452,997	751
Young trees	96,652	1,254			
Specimen evergreens	156,659	1,570	Total		22,600
Young evergreens	3,361,730	9,739			
Seedlings, cuttings, and small plants	1,343,477	2,464			

[1] Where the stock came from sections regulated by the quarantine on the Japanese beetle, certification covered this pest also.

TABLE 10.—*Evergreen products, forest products, stone and quarry products, and steel rails certified under gypsy moth quarantine, fiscal year 1937*

Material	Quantity	Certificates issued	Gypsy moths found	
			Egg clusters	Larvae and pupae
Evergreen products:		*Number*	*Number*	*Number*
Boughs, balsam twigs, and mixed greens—boxes or bales	21,646	3,938	19	
Christmas trees—number	634,365	1,361		
Laurel—boxes or bales	8,740	2,346	4	
Miscellaneous—boxes	12,559	10,525		
Total		18,170	23	
Forest products:				
Barrel parts, crates, crating—bundles, cases	80,932	1,093	3	
Logs, piles, posts, poles, ship knees, and ties—carloads	5			
Logs, piles, posts, poles, ship knees, and ties—pieces	665,163	3,148	60	2
Fuel wood—cords	5,308	388	2	
Pulpwood—do	60,671	2,071		
Lumber—board feet	45,807,767	5,492	961	311
Empty cable reels—number	20,144	3,328		34
Shavings—bales	43,291	202		
Shrub and vine cuttings—boxes	9,635	1,101		
Miscellaneous—bundles, boxes	532,613			
Do—pieces	91,357	1,739	76	8
Do—tons	1,265			
Total		18,562	1,102	355
Stone and quarry products:				
Crushed rock—tons	665	55		2
Curbing—running feet	171,122	383		
Feldspar—tons	8,560	429		
Granite—pieces	124,552	5,816	10	
Monumental stone—do	23,089	16,297		
Grout—tons	43,966	547	1	
Marble—pieces	678	345		
Paving blocks—number	2,193,751	403		
Miscellaneous—pieces	96,300	514		
Total		24,789	11	2
Steel rails [1]—carloads	12	26	64	

[1] From abandoned railway lines.

DUTCH ELM DISEASE ERADICATION

GENERAL STATUS

Results of the year's campaign encourage the belief that the Dutch elm disease (*Ceratostomella ulmi*) can be eradicated from the United States. A nominal increase in extent of the infected zone may be attributed in great measure to increased scouting activities and more thorough coverage. The successful cooperation of Federal and State agencies, the improvement of scouting, sanitation, and removal methods, and sufficient W. P. A. funds for skilled and unskilled labor are the major factors which account for the greater smoothness, continuity, and progress made this year. Larger and better trained forces of scouts were in the field considerably earlier in the foliar season than in 1935. Particular attention was paid to clear-cutting operations in swamp districts and to railroad scouting.

SYSTEMATIC SCOUTING

Up to the beginning of the year the established cases of Dutch elm disease had totaled 15,485, including 160 cases in Connecticut, 10,109 in New Jersey, 5,156 in New York, and 60 in isolated infection centers.

Intensive systematic scouting for diseased trees began about July 1 and continued until the middle of September. A maximum of 3,110 W. P. A. scouts were employed during the season. At the peak of the season 550 C. C. C. enrollees were assigned to systematic scouting in woodland areas. By August 29, 683 crews were in the field.

A much larger and better-trained force of scouts was placed in the field this year. A large proportion of the men chosen could already identify elms and climb, so that training was concentrated on scouting technique and the recognition of symptoms of the disease. Scout schools did not close until the middle of August. An authorization received on July 23 for an increase from 10 percent to 30 percent in the personnel not drawn from relief rolls that could be hired on W. P. A. funds assisted materially in relieving the difficulties that had been encountered in filling requisitions placed with local W. P. A. offices. Authority for 143 W. P. A. supervisory appointments of experienced men to work full time also greatly assisted in completion of the season's scouting program, both in the major infected zone and at outside points. Progress in the season's scouting in most sections at the end of July was equivalent to the accomplishments late in August in 1935.

Scouting activities during 1936 more nearly approached the scheduled three surveys of the entire work area than in any previous year, notwithstanding increases in territory as a result of current findings. In addition to one complete survey of the entire infected area, the Connecticut infected zone was completely scouted on a second and a third survey. Approximately 85 percent of the infected areas in New Jersey and New York were covered a second time, while 40 percent of the New Jersey infected area and 65 percent of the New York infected zone were scouted on the third survey. Scouting of the 10-mile protective area was 100 percent complete in Connecticut and New Jersey in the first survey; approximately 30 percent complete in Connecticut and 75 percent complete in New Jersey in a second survey; and negligible in the third survey. Scouts in a cruising auto covered approximately 25 percent of the protective area in New York.

During the foliar season only 22 diseased trees, as against 39 in 1935, were discovered by scouts assigned to isolated cities in which infection had previously been discovered. Cleveland and Cincinnati, Ohio, and Brunswick, Md., showed no evidence of the disease this year. One diseased tree each was found in Baltimore, Md., and Norfolk, Va., and 19 suspected cases were confirmed in Indianapolis. The only isolated first-record infection discovered in 1936 was that found by railroad foot scouts in a wood lot approximately one-half mile beyond the eastern limits of the Baltimore & Ohio freight yards in Cumberland, Md. Discoloration in the elm was noted in the 1934, 1935, and 1936 annual rings.

Organization of railroad scouting activities was completed August 2 and the work continued until the last week in September. Men with from 1 to 3 years' experience were selected for this work. One four-man crew on foot scouted the Baltimore & Ohio right-of-way from Harpers Ferry to Clarksburg, W. Va. Ten two-man crews in cars scouted the other railroads over which imported elm logs traveled to veneer mills, paying particular attention to junction and freight make-up points. Railroads worked to the Middle West were the New York Central, Erie, Pennsylvania, Baltimore & Ohio, and Lackawanna, from New York City; the Western Maryland, from Baltimore; the Norfolk & Western from Norfolk; the Southern, Illinois Central, Louisville & Nashville, and Missouri Pacific, from New Orleans; and the Big Four and Nickel Plate in New York, Pennsylvania, Ohio, and Indiana. Kansas City was the westernmost city scouted. This is the first season that these routes have been completely surveyed by the scouting force. In addition to the finds of diseased trees at isolated points, an infestation of the smaller European elm bark beetle was discovered at Parkersburg, W. Va.

Since the smaller European elm bark beetle is the most important insect vector of the Dutch elm disease in this country, the scouts returned to Parkersburg, W. Va., to determine the extent of the infestation. The infested area, comprising approximately 7,500 square miles, is roughly bounded by Wheeling, Glenville, and Charleston, W. Va.; and Ironton, Wellston, Athens, and McConnelsville, Ohio. An intensive search was made in this area for diseased trees, with negative results. Surveys in the Ohio and West Virginia *Scolytus* area were completed December 11. Sixty specimens of beetle galleries and trunk samples collected and sent to the laboratory to be tested for *Ceratostomella ulmi* gave negative cultures.

The success of aerial scouts in locating wilted elms last year led to the purchase of three additional autogiros for the scouting of areas not easily covered in any other way. Using aerial photographic or township maps, on which the aerial observers had indicated locations of wilted elms, ground crews were able to locate, sample, and tag any such tree showing symptoms typical of the Dutch

elm disease. An area of approximately 2,142 square miles was covered by two autogiro crews in the New Jersey protective zone and in Orange County, N. Y. Out of a total of 667 individual and 36 groups of wilted elms spotted, 8 trees were confirmed as having the Dutch elm disease. The cost of scouting 500 square miles by autogiro, including the initial outlay for the plane and aerial maps, is about one-fourth that of scouting the same area on foot.

A first attempt at an elm census was made by scouting crews in conjunction with their regular duties. The total elm population of the present work area was estimated to be 11,500,000. New Jersey leads with 4,800,000, followed by New York with 4,000,000, Pennsylvania with 2,500,000, and Connecticut with 200,000.

Early-season wilting typical of the Dutch elm disease was first observed in 1937 on an elm in the town of Patterson, Putnam County, N. Y., on May 24. General wilting of elm foliage was observed early in June.

By June 1, 1937, approximately 1,300 scouts were in scout training schools. Systematic scouting began during the first week in June. By the end of the fiscal year 3,159 scouts were in the field, the large majority of whom were paid from work relief funds. Of those engaged in the work, 391 were from the C. C. C.

On May 21 four two-man scouting crews, one supervisor, and an autogiro with a pilot left for Montgomery, Ala., to begin systematic scouting of railroads in Alabama, Arkansas, Georgia, Indiana, Kentucky, Louisiana, Mississippi, Missouri, Oklahoma, Tennessee, Virginia, and West Virginia. The purpose of the flight was to complete a survey of the roads over which elm logs had been shipped. Approximately 225 miles of railroad right-of-way were covered each flight day. Aerial scouting over rough terrain in the New Jersey and New York work areas was under way by the middle of June.

Six additional cases of diseased elms in Indianapolis were confirmed before the end of the year. Total infected trees recorded to date in outlying areas are as follows: Indianapolis, Ind., 39; Baltimore 2, Brunswick 3, and Cumberland 1, in Maryland; Cleveland 33, and Cincinnati 1, in Ohio; and Norfolk, Va., 5; or 84 in all.

Samples were collected during the year from 59,661 trees showing apparent symptoms of the disease. Of these, 7,640, upon examination of the cultures, were confirmed as infected with the Dutch elm disease. Segregated by States, 109 were in Connecticut, 5,802 in New Jersey, 1,705 in New York, and 24 at isolated infection points in Indiana, Maryland, Ohio, and Virginia. Compared with the previous year there was a 16-percent increase in the number of confirmations. Last year the comparative increase was 17 percent.

On the basis of the 1936 foliar season, 7,327 cases were confirmed as compared to 5,664 during the 1935 foliar scouting season. The increase may be largely attributed to more efficient scouting over a longer period during the 1936 season. Results are definitely promising in view of the lack of spread from previous years' heavily infected area, and the slight increase in disease cases at the margin of the zone infected in 1935.

The grand total of known disease cases on record in the United States on June 30, 1937, is 23,125, of which 269 occurred in Connecticut, 15,911 in New Jersey, 6,861 in New York, and 84 at 7 isolated infection centers.

EXTENSIONS OF WORK AREA

Trees infected with the Dutch elm disease were found in or just outside the 10-mile protective zone at Branford and Guilford, Conn.; at Hopewell in Mercer County and Fairhaven, Holmdell, Little Silver, and Oceanport in Monmouth County, N. J.; and at six points in Orange County, and Huntington in Suffolk County, N. Y. The infected tree at Huntington was 6 miles from the nearest previous infection. The major diseased area, enlarged to circumscribe the newly discovered infections, included at the end of the year 276 square miles in Connecticut, 2,943 in New Jersey, and 1,914 in New York, a total of 5,133 square miles. The increase for the year was 826 square miles. The 10-mile protective zone included at the close of the year 727 square miles in Connecticut, 895 in New Jersey, 708 in New York, and 720 in Pennsylvania—3,050 square miles in all. The total work area of 8,183 square miles is approximately equal in extent to the entire State of Massachusetts.

There are a number of areas in the heavily infected zone in which known infections of the disease have been reduced to a small percentage of previous years' confirmations. Staten Island in New York, N. Y., is a good example of

greatly reduced infection. During 1934 653 diseased trees were found on the island, evidencing quite a concentration in that limited area. Infections found in 1935 numbered 327. This year only 69 cases could be found. Pronounced reductions in infections were also noted in the Bronx and in sections in the lower part of Westchester County, N. Y. Confirmations were also considerably reduced in many townships of Essex County, N. J., the county containing the heaviest infection in the State. In Caldwell Township, for example, annual confirmations from 1934 to date were 177, 398, and 41. This is particularly encouraging since this township contains a great number of elms that the disease might attack.

An amendment, effective November 9, 1936, to the regulations supplemental to Notice of Quarantine No. 71 added to the regulated area the towns of Ridgefield and Wilson in Fairfield County, Conn., where newly discovered infections were found. In New Jersey all except 5 townships and 4 boroughs in Hunterdon County, 1 township and 2 boroughs in Mercer County, all except 2 townships and 3 boroughs in Middlesex County, 2 townships and 17 boroughs in Monmouth County, all except 4 townships in Sussex County, and 3 townships and 3 boroughs in Warren County were included in the regulated area. Added areas in New York State were three towns in Orange County and one in Suffolk County.

ERADICATION AND SANITATION ACTIVITIES

Laboratory culturing of samples collected by sanitation crews from felled trees showing wood discoloration continued to emphasize the importance of ridding the infected zone of dead and devitalized trees that might be infected without showing the usual wilting symptoms and in addition are favored breeding places for the several species of bark beetles infesting the work area. In an attempt to speed up elm sanitation work by the quick removal of standing dead and dying elms already tagged for destruction, requests were placed on August 20 with the W. P. A. for 2,600 additional workers. At the beginning of the year 366,467 such trees awaited removal. In addition 758 elms in which infection had been confirmed were awaiting destruction.

Sanitation crews began work in the field under the fall program on October 8, 1936, in New York and Connecticut and on October 12 in New Jersey. W. P. A. quotas of men for the various fall activities in the respective States were approximately 380 in Connecticut, 3,600 in New Jersey, and 1,500 in New York.

Thousands of devitalized elms in swamp areas, which by their location are difficult and expensive to scout and to maintain in a healthy condition, succumbed to a newly devised chemical treatment. The method was used in sections of the 10-mile barrier strip about the periphery of the major diseased zone. To date, 624,850 trees have been thus chemically treated.

An extensive project for the removal of dead trees was undertaken in the vicinity of the first-record infection discovered at Cumberland, Md. Approximately 14,000 dead trees were cut down in a 4-mile strip stretching on either side of the center of infection. Devitalized elms were carefully pruned in adjacent sections. No Dutch elm disease was found when 60 specimens showing streaking of the wood were submitted to the laboratory for culturing, although *Verticillium* infection was present.

Pruning of trees has been carried out in a few localities. In Westchester County, N. Y., pruning extended 500 feet around isolated trees confirmed as to infection, and in Cleveland all elms within one-half mile of confirmed trees were pruned.

During the year sanitation crews removed 7,802 elms in which infection had been confirmed and 837,315 dead and dying elms. In addition, clear-cutting crews removed 789,685 trees. At the end of the year there remained standing, ready for removal and eradication, 596 diseased trees and 337,058 dead and dying elms. The grand total of elms removed to date in clear cutting, eradication, and sanitation activities is 3,324,515.

IMPROVED METHODS OF SCOUTING AND ERADICATION

Autogiros were used extensively during the year with great success, particularly along railroad rights-of-way over which imported burl elm logs had traveled to veneer mills and over rough terrain. Scouts had little difficulty in locating the wilted trees from the prepared aerial maps.

An experimental trunk-sampling project in cooperation with the Division of Forest Pathology of the Bureau of Plant Industry compared the efficiency of

trunk sampling with the routine procedure of climbing trees to obtain samples. The number of diseased trees found in the experimental wood lot was more than doubled by the use of the trunk-sampling method. This method has been employed at the Guilford and Old Lyme infection centers and in the Tamarack swamp area, Connecticut.

Clear-cutting operations, particularly in swamp areas, were facilitated by power-saw units. Four such units were used in the removal of trees in Morris, Bergen, Essex, and Union Counties, N. J. Large trees ordinarily requiring 2½ to 3 days for removal by hand crews have been cut by power saw in from 6 to 8 hours.

CIVILIAN CONSERVATION CORPS COOPERATION

Contributions to Dutch elm disease eradication work by the C. C. C. were materially reduced by the abandonment during the year of three of the six camps originally devoted to this work. One of the two camps in New York State was disbanded by April 10. The camp in Connecticut was ordered closed on May 24, and the camp at West Milford, Passaic County, N. J., was closed on June 30, leaving two camps in New Jersey and one in New York. C. C. C. enrollees participated in all phases of the work, under the supervision of experienced men trained and recommended by the Bureau.

SOURCES OF FUNDS

Funds allotted for Dutch elm disease eradication work included a regular departmental appropriation of $261,156 and W. P. A. allotments amounting to $4,258,875. The State appropriations for cooperative work amounted to $100,000 in New York, $39,100 in New Jersey, and less than half of a $25,000 biennial appropriation in Connecticut. New York funds were available for the employment of a small part of the scout force, for eradication by State crews or private contractors of all trees in the State confirmed as to infection, and for public-relations work necessary to secure authority for removal of the trees. Federal assistance was necessary to augment the limited contact work that could be performed under available New Jersey and Connecticut funds.

The work was again greatly assisted this year by the mutually helpful cooperation accorded the Bureau by officials of the three States.

INFORMATIONAL ACTIVITIES

On July 29 representatives of the Paramount News Corporation made sound shots of power saws, scouts at work, an autogiro in operation, the Morristown, N. J., laboratories, and maps showing the distribution of the disease in the United States. A comprehensive exhibit was set up for the annual convention of the American Association of Economic Entomologists in Atlantic City in December. Several radio talks and newspaper and magazine articles were prepared for release during the year.

WHITE PINE BLISTER RUST CONTROL

PROTECTIVE WORK CARRIED OUT ON 4,400,000 ACRES IN 1936

The use of relief labor made it possible to continue vigorously during the year the program of white-pine blister rust control. Through the employment of some 14,000 men directly supervised by this Bureau during the summer of 1936 and approximately 6,000 assigned to the work from the C. C. C. camps and other sources, more extensive forest areas were protected from this fatal tree disease than in any previous year.

Stands of the several economic species of white pine are permanently protected from blister rust infection when the currant and gooseberry plants (commonly called *Ribes*) are removed from among the trees, and for a protective zone of 900 feet on all sides of the stands, and when by occasional subsequent checking the area is maintained free from such plants throughout the life of the pines. During the field season of 1936, 4,404,066 acres were so protected, of which 3,340,179 acres consisted of initial work, and 1,063,887 consisted of areas covered one or more times previously since 1918. This work involved the destruction of 203,217,239 *Ribes* and required 1,075,621 man-days of labor.

The details of these *Ribes* eradication operations are given in table 11.

TABLE 11.—*Ribes eradication operations for the calendar year 1936*

Region	Area covered			Effective labor [1]	*Ribes* destroyed
	Initial work	Rework of areas covered 1 or more times previously	Total initial and rework		
	Acres	*Acres*	*Acres*	*Man-days*	*Number*
Northeastern States	1,048,305	736,073	1,784,378	827,574	55,742,673
Southern Appalachian States	1,169,073	244,196	1,413,269	44,717	55,804,474
Lake States	628,214	56,416	684,630	190,929	7,741,501
Western white pine (Idaho, Montana, Washington, including Mount Rainier)	297,781	16,043	313,824	214,868	55,415,237
Sugar pine (California and Oregon)	179,163	11,159	190,322	90,686	27,675,865
Rocky Mountain States (Colorado and Wyoming)	17,643		17,643	6,847	837,489
Total	3,340,179	1,063,887	4,404,066	1,075,621	203,217,239

[1] Reported as effective 8-hour man-days; the time actually worked ranged from 6 to 8 hours per day.

OVER 10,000,000 ACRES OF PINE NOW UNDER PROTECTION FROM BLISTER RUST

The control work is aimed at protecting forest areas containing a sufficient stocking of white pine to produce a good crop of timber at maturity and making these areas safe for the continued production of white pine. Accordingly, in selecting forest tracts to be included in the control areas, preference is given to the better sites and more valuable stands of young growth.

It will be noted from table 12 that initial protection through *Ribes* eradication has now been given to 18,572,799 acres of control areas. This has resulted in the protection of some 10,000,000 acres of pine forest. Of the control area, 3,200,721 acres have been reworked. This protection has been accomplished during the past 19 years through the destruction of 756,662,550 *Ribes*.

TABLE 12.—*Status of white pine blister rust control on Dec. 31, 1936*

Region	Total pine area of sufficient value to justify protection [1]	Control area, including border zones [1]	Work accomplished 1918–36			
			Initially protected control area	Rework areas subsequent to initial protection	Effective labor [2]	*Ribes* destroyed
	Acres	*Acres*	*Acres*	*Acres*	*Man-days*	*Number*
Northeastern States	7,667,127	12,572,879	11,221,205	2,678,986	1,905,813	217,255,718
Southern Appalachian States	1,275,081	3,831,204	3,347,745	290,739	105,807	12,624,012
Lake States	1,254,394	4,260,757	1,796,831	107,673	585,545	152,381,410
Western white-pine area	2,710,129	2,710,129	1,625,712	79,097	1,249,539	301,886,409
Sugar-pine area	2,200,316	2,200,316	555,280	44,226	243,749	71,443,579
Rocky Mountain States	394,548	394,548	26,026		9,056	1,071,422
Total	15,501,595	25,969,833	18,572,799	3,200,721	4,099,509	756,662,550

[1] Figures on pine and control areas are repeated from the 1936 report and are lower than will be shown after pre-eradication surveys now in progress are completed.

[2] Reported as effective 8-hour man-days; the time actually worked ranged from 6 to 8 hours per day.

In table 12 the acreage of pine area and of control area is repeated from the figures given in the last annual report. Such pine mapping as has been carried on during the past year indicates that these total acreage figures are somewhat too low. The remaining control area which should be covered is, accordingly, considerably greater than the difference between the acreages of the control areas and the initially protected areas, as shown in the table, would indicate. It is anticipated that during the fiscal year 1938 the pine and control-area mapping project will have made sufficient progress so that the first two columns of this table can be brought up to date in the next annual report.

EXTENSIVE AREAS OF PINE STANDS MAPPED

For several years considerable numbers of relief laborers under careful supervision have been assigned during the winter months to the preparation of maps showing the location and boundaries of white pine stands. The work is done during a season of the year when *Ribes* eradication cannot be carried out efficiently. During 1936, 4,169,628 acres were so mapped, this acreage including not only the pine stands contained therein but also the area of the surrounding control zone. Such mapping has been carried out during the last several years on 15,938,569 acres of control area, most of the work having been done since 1932. These maps are proving a great aid to *Ribes* eradication during the summer.

CULTIVATED EUROPEAN BLACK CURRANT DESTROYED IN LARGE NUMBERS

Several of the so-called black currants are so highly susceptible to blister rust and distribute blister rust spores in such tremendous numbers that they constitute an exception to the general rule that a 900-foot border zone around pine stands is sufficient to provide protection. The Department accordingly recommends that they be destroyed throughout white pine regions. Two such susceptible species exist in the Pacific Northwest (*Ribes petiolare* and *R. bracteosum*). The first of these grows in large numbers along some of the creeks in the western white pine region of Idaho and is destroyed by the use of chemical sprays. The other is not a problem in the principal western white pine areas but is of importance locally in parts of the Cascade Mountains and Sierra Nevada.

Of the cultivated species, the European black currant (*Ribes nigrum*) is by far the most susceptible, and most of the pine-growing States have accordingly outlawed this species completely. It was originally planted in considerable numbers in the Northeastern States, but was the subject of a general eradication campaign throughout that area 5 to 10 years ago, so its elimination has now been largely accomplished. A like campaign was carried out about the same time in the Northwestern and Pacific Coast States where western white pine and sugar pine are of commercial importance. Since emergency relief labor became available, the Lake States have been engaged in a similar program. During 1936, 87,226 *Ribes nigrum* were eradicated, nearly all of which occurred in the Lake States region.

APPROVAL OF MANY NURSERIES FOR PINE PRODUCTION

Reforestation has expanded on a tremendous scale since the organization of the C. C. C., Soil Conservation Service, and other recently established agencies. The nurseries producing the trees for the reforestation program have included large numbers of white pines in their stock, and accordingly it has become necessary to carry out extensive *Ribes*-eradication programs around these nurseries in order that the young pine trees produced therein may be healthy at the time they are sent out. The nurseries that succeed in maintaining freedom from *Ribes* in their environs are issued Federal permits which enable them to ship their white pine stock interstate.

Such nursery sanitation work was carried out in 1936 in and around 93 nurseries, of which 32 were located in the Northeastern States, 18 in the southern Appalachian region, 41 in the Lake States, and 2 in the western white pine area. These nurseries were growing 134,175,374 white pines. In protecting them, 1,058,518 *Ribes* were destroyed in 1936 on 49,781 acres.

BLISTER RUST CANKERS MAY BE CUT OUT ADVANTAGEOUSLY ON VALUABLE PINES

In some cases a single blister rust canker is sufficient to girdle and kill a pine tree, while in other instances many hundreds of cankers kill all the individual branches and thereby destroy the tree. The cankers increase in size so long as the trunk or branch on which they are growing continues to live, and branch cankers, accordingly, frequently reach the trunk and kill the tree, though in the case of large trees this may take from 5 to 20 years or longer.

During this period of growth the removal of the canker will often save individual trees of high esthetic value, a method which has been employed effectively in such places as parks and along roadsides. To a limited extent, canker removal has been tried in the State forests of New York in connection with pruning, thinning, and other work for improvement of stand.

In 1936, 167,425 cankers were removed in this manner from 73,713 white pines in the northeastern, southern Appalachian, and Lake States regions. Of the 586,371 trees examined in connection with canker elimination, 51,669 were found to be so far gone that they could not be saved, and the trees were removed. Employment on the canker-elimination project totaled 6,329 man-days during the year.

LABOR FOR BLISTER RUST CONTROL COMES LARGELY FROM RELIEF SOURCES

The accomplishments outlined in this report include not only the work directly carried out and administered under allotments to the Bureau of Entomology and Plant Quarantine, but also the accomplishments of all cooperating agencies in white-pine blister rust control. This Bureau, through memoranda of agreements and otherwise, has recognized leadership over the entire program and is responsible for pine and disease surveys, checking the maintenance of efficient standards of *Ribes* eradication, and similar matters with respect to such cooperating agencies, the degree of direct administrative responsibility varying in different cases. A considerable proportion of the labor cost is borne by the agency administering the forest concerned, or by the State, county, or private owner of the land.

Of the acreages recorded above, 3,622,402 were covered during 1936 by eradication crews paid under allotments from Emergency Relief Appropriation Acts of 1935 and 1936 direct to the Bureau of Entomology and Plant Quarantine. The C. C. C., in addition, covered 689,347 acres, devoting 285,954 effective 8-hour man-days to this purpose. The remaining acreage of 92,317 was financed by numerous other cooperating agencies. One of the largest non-Federal cooperators was the State of Idaho, which carried most of the expense of *Ribes* eradication on 11,133 acres of State-owned western white pine.

In the case of the C. C. C., that part of the work which was carried on in the national forests was handled by camps assigned to the Forest Service of this Department. The work in the national parks was undertaken by camps allotted to the National Park Service of the Department of the Interior. The work on private and State land was, in most cases, carried out by camps working under the direction of the State forester, the Soil Conservation Service, or the Resettlement Administration.

The use of relief labor for white-pine blister rust control has proved to be a highly desirable arrangement from many standpoints. It is vigorous, active outdoor work, carefully and continuously supervised, and has thus been highly beneficial to the morale, health, and physical well-being of the men concerned. Most of the laborers on *Ribes* eradication have been obtained in the immediate localities in which the work was being done, and have thus become familiar with blister rust and the methods of protecting pine stands against it. While laborers drawn from relief rolls do not cover the ground quite as rapidly or efficiently as those who might be picked individually on account of their energy and physical ability, it is probable that under no other conditions could the protection of such large areas of pine forests have been accomplished. The saving of this national-forest resource from a fate similar to that which destroyed the chestnut trees may thus be considered one of the important accomplishments resulting from the relief program.

PINE INFECTION SPREAD LITTLE IN 1936

While *Ribes* eradication protects the individual stands from which the currant and gooseberry plants are removed, the blister rust, of course, continues to spread in unprotected areas, including those forested regions in which white pines are scattered and of little or no commercial value. The new areas reached by the disease can be determined by examining the leaves of currant and gooseberry plants.

In the Northeast, blister rust infection is general throughout the white pine range in New England and New York, the amount of disease varying considerably in different localities. In Warren and Essex Counties, N. Y., and in the upper Connecticut River Valley section from 10 to 95 percent of the trees bear blister rust cankers in unprotected areas. Infection extends southward from New York State across Pennsylvania and New Jersey to Maryland, Virginia, and West Virginia.

In Maryland the disease seems to have been present in Allegheny and Garrett Counties since 1924, and has now been found in each county west of the District of Columbia. In Virginia the rust has been found in 10 counties in the pine belt, north of the center of the State, except Albermarle, Greene, Shenan-

doah, and Warren Counties, where it is probably present but has not been reported. No additional Virginia counties were reported infected in 1936, although several infected localities were reported for the first time in Highland and Rockingham Counties and in the George Washington National Forest. In West Virginia the rust was very scarce in 1936, the only infection found being on two cultivated bushes in one locality in Pendleton County. Four West Virginia counties have been reported infected in past years, namely, Pendleton, Pocahontas, Randolph, and Tucker.

In the Lake States, counties in which pine infection was found for the first time in 1936 include Keweenaw, Muskegon, Saginaw, St. Clair, and Schoolcraft in Michigan; Buffalo, Door, Eau Claire, Langlade, Outagamie, Price, Sheboygan, Vilas, Waushara, and Winnebago in Wisconsin; and Hubbard and Todd in Minnesota. During the same year it was found on *Ribes* for the first time in Buffalo, Fond du Lac, Manitowoc, Sauk, Sheboygan, and Winnebago Counties, Wis., and in Koochiching County, Minn. During the period from January 1 to June 30, 1937, further counties reported for the first time with infections on pine included Manitowoc, Brown, La Crosse, Monroe, and Sauk in Wisconsin.

The principal development in the West was the tentative delimiting of the infection in California, which, as reported last year, was first discovered on June 26, 1936. The surveys including and immediately following this discovery showed the presence of blister rust in Del Norte County on one sugar pine near Monumental and on one *Ribes* on Rowdy Creek; also in Siskiyou County on several sugar pines and *Ribes* on Indian Creek, and on two *Ribes* on Goff Creek and the Applegate River, respectively. Surveys in Oregon carried out at the same time showed sugar pines infected in Coos, Curry, Jefferson, and Lane Counties; western white pine infected in Curry and Lane Counties; whitebark pines infected in Hood River and Clackamas Counties, and *Ribes* infected at several points in Curry County and on Clear Creek in Josephine County. Blister rust occurs generally on *Ribes* in the northwestern quarter of Oregon which was not included in this survey.

In the "Inland Empire" of Idaho, eastern Washington, and western Montana, a pine-disease survey initiated in 1935 was continued in 1936 on a large scale, using especially chosen security-wage workers for the purpose. Strips 1 rod wide were run on each section line crossing all the important roads through the forest areas concerned. The results showed, as a general average, that 4.4 percent of the trees examined were infected in the St. Joe National Forest, 3.8 percent in the Clearwater National Forest, 1 percent in the Kaniksu National Forest, 0.5 percent in the Kootenai National Forest, and 0.2 percent in the Mount Spokane area. Special scouting strips were also run through portions of these forests which were known to be infected. In the territory scouted on these strips it was found that 6.8 percent of the pines examined were infected on the St. Joe National Forest, 4.3 percent on the Coeur d'Alene National Forest, 6.4 percent in the Kaniksu National Forest, 8.5 percent in the Cabinet National Forest, and 2.8 percent in the Mount Spokane forest area. The number of white pines examined on the regular strips was 289,765, while on the scouted strips 115,599 pines were checked. The infection reports relate only to trees below 20 feet in height. The heaviest infection recorded (81 percent) was in that part of one of the areas in the St. Joe National Forest located within 300 feet of a stream bed on which *Ribes petiolare* was present.

IMPROVED METHODS DEVELOPED

In further studies to increase the efficiency and to reduce the cost of *Ribes* eradication, it was found that the common species of prickly gooseberry (*R. roezli*) in California could be destroyed most effectively by cutting off the top of the plant and applying oil to the crown. One oiler with a knapsack spray tank accompanies a crew whose members pull the small *Ribes* and cut off the tops of the larger bushes. Diesel oil is then applied by the oiler, using a sprinkling hose attachment to the tank. From 5 to 6 gallons of oil are used per 100 treated plants.

Preliminary tests also indicate that dense masses of *Ribes* seedlings, which often occur in recently burned or disturbed areas, can be killed at reduced cost by spraying with oil.

Promising results of chemical-treatment tests are also being obtained in Colorado and Wyoming in a search for methods of *Ribes* eradication applicable to forest areas where the limber pine (*Pinus flexilis*), the whitebark pine (*P. albicaulis*), and the bristlecone pine (*P. aristata*) are of importance for watershed protection and other purposes.

ENFORCEMENT OF THE WHITE PINE BLISTER RUST QUARANTINE

The regulations of the white pine blister rust quarantine require a Federal pine-shipping permit in the interstate movement of five-leaved pines from the infected States to any State other than New York or the New England States. Such permits are issued only for five-leaved pines which have been grown under specified sanitation conditions. Applications for shipping such pines in the fiscal year 1938 have been received from 57 nurseries. The work of eradicating currant and gooseberry plants, the alternate hosts of the disease, from the sanitation zones surrounding these nurseries and of inspecting the zones to insure compliance with the quarantine regulations was completed in the spring of 1937 prior to the time when the rust normally appears on such plants. The environs of nurseries of 50 applicants were found to be in a satisfactory condition, including 14 Federal and 9 State nurseries growing five-leaved pines for soil conservation or reforestation purposes.

The States of Wisconsin, Ohio, Pennsylvania, and Maryland recently established white pine blister rust control areas for the purpose of protecting valuable stands of five-leaved pines. In such areas the planting and possession of currant and gooseberry plants is prohibited under State authority. The Federal quarantine was accordingly revised, effective March 1, 1937, to provide that no currant or gooseberry plants may be shipped to these States without a control-area permit, obtained from the responsible officer of such State. Fourteen States now have legally established blister rust control areas.

During the year 110 violations of the quarantine regulations were intercepted by transit inspectors, and 94 were intercepted by roadside inspectors of other projects.

CEREAL AND FORAGE INSECT INVESTIGATIONS

INSECTS ATTACKING CORN

Surveys of European corn borer populations in 1936 show that in western Ohio and in the southeastern counties of Michigan, where moisture conditions approached the normal, there were significant increases in the rate of infestation over those observed in 1935. In the drier areas, such as eastern Indiana, southwestern Ohio, parts of Michigan, and the Eastern Shore of Maryland, definite decreases in infestation were indicated. Significant increases in the rates of infestation were recorded in parts of Vermont, Massachusetts, Connecticut, Rhode Island, and New Jersey. In spite of the decrease in infestation in some areas as a result of drought conditions, the loss resulting from borer attack was higher in 1936 than in any previous year, owing in part to the increased value of the corn crop. A second generation of borers appeared in significant numbers in the Great Lakes area previously considered as a one-generation area. Experiments with these borers during the year indicate that the two-generation individuals may be physiologically different from the one-generation strain but not physiologically identical with the multiple-generation strain. Whether the two-generation habit occurring in these areas in 1936 will persist is unknown. Adult corn borer parasites to the number of 35,488 were released in 35 colonies in 10 States. This material was obtained from European and oriental importations, from domestic collections in Massachusetts, and from material originating from Canada which was reared in the laboratory, and included the following species: *Inareolata punctoria* Roman, *Microgaster tibialis* Nees, *Cremastus flavorbitalis* Cam., *Ludella grisescens* R. D., and *Chelonus annulipes* Wesm. *I. punctoria* and *L. grisescens* appear to be particularly effective, and *C. annulipes* shows much promise in the Lakes area. A method has been developed for rearing this last-mentioned species on the Mediterranean flour moth to supply adults for colonization. Investigations of inbred lines of field and sweet corn show several of both types carrying marked resistance. The most important development in this work in 1936 is the demonstration that a considerable degree of resistance is inherent in one of the most favorable crosses, and this is not explained by the tightly wrapped tassel of this strain—a character to which most of the resistance in this line had previously been ascribed. Not only is there a large reduction in the number of borers surviving in this strain when infested previous to tasseling, but those borers that survive are stunted and lack vitality to meet winter conditions. In an extensive test of inbred lines of sweet corn certain lines exhibited resistance that is not associated with date of planting or the eclosion of the tassel, thus giving encouragement for further work of this character. Detailed studies, however, have indicated that date of

planting is an important factor in determining amount of infestation and that degree of resistance varies with the age of the plants.

Infestation by the corn earworm was relatively low in the summer of 1936, owing both to the severe drought and to the very severe weather conditions that prevailed in the previous winter. The results of hibernation studies during the winter indicate that this insect hibernated successfully considerably farther north in the winter of 1936–37 than in the previous winter, and as a consequence it appeared much earlier and in greater abundance in 1937. In studies conducted cooperatively by the Bureau of Plant Industry and the Illinois Agricultural Experiment Station, a large series of double crosses, single crosses, inbred lines, open-pollinated varieties, and top crosses were studied to determine their relative susceptibility to corn earworm attack. Although the data secured are only preliminary, 34 double-cross hybrids, 11 single crosses, 8 inbred lines, and 6 varieties showed possibilities of having resistance and are being given additional more severe tests. A method of artificial infestation has been developed and is being utilized to secure a uniform infestation irrespective of fluctuations in the normal field population. Investigations on insecticides for the control of the corn earworm, conducted at New Haven, Conn., in cooperation with the Connecticut Agricultural Experiment Station, and in Florida, have not revealed any outstanding insecticide for field application. The use of a fumigant (hexachloroethane) in paper caps for covering high-value sweet corn for protection against the earworm has been highly effective and may be feasible under special conditions. The method, however, requires further development.

INSECTS ATTACKING SMALL GRAINS

The hessian fly was at a low ebb as a result of unfavorable climatic conditions. It has been possible, however, to maintain fairly high infestations in nursery plots, and the general low populations have not seriously interfered with the work on hessian fly resistance in wheats that is being conducted in cooperation with the Bureau of Plant Industry and the agricultural experiment stations of California, Kansas, and Indiana. A number of additional varieties of wheat have been discovered to have some resistance to the hessian fly. Although these are confined primarily to spring wheat varieties, evidence has been obtained that the resistance inherent in spring varieties may be transferred to fall-sown wheats by hybridization. In California a distinction has been recognized between those wheats having two factors for resistance and others having less stable or lower degree resistance represented by derived one-factor lines. Previous results have indicated a marked difference in the reaction of given varieties of wheat to California flies as compared with the same varieties of wheat when exposed to Indiana flies under Indiana conditions. Investigations during the year have indicated that this difference in the reaction is in some degree due to biological strains of the flies rather than to differences in vegetational growth due to differences in environmental conditions. There is a marked difference between the ability of California and Indiana flies to infest the same varieties of wheat under similar climatic and soil conditions. Evidence has been accumulated, however, which indicates that resistance or susceptibility to fly attack may be materially influenced in some cases by modifications of plant structures as a result of environmental differences. Resistant types of wheat in the jointing stage have been shown under some conditions to be more susceptible to the hessian fly than when in the fall, or rosette, form. Infestation tests of wild grasses show that hessian fly larvae may develop on numerous species of wild grasses. Strains of these grasses vary greatly in resistance. Susceptibility to infestation appears to be correlated with the character of the tissues of the leaf sheaths. Usually, although not invariably, the grasses found to be most susceptible have stems that are soft and yielding. Preliminary results indicate a previously unrecognized direct correlation between the mortality in winter wheat and the extent of hessian fly infestation. Detailed studies of the relation of the developing larvae to the tissues of the fly-resistant and susceptible wheat plants show that the first-instar larvae on certain resistant plants are apparently generally prevented from molting by the pressure of the harsh tissue of these plants. The few larvae which molt and develop on these resistant plants are usually distorted by pressure of the leaf sheaths, while larvae on susceptible plants survive the first molt successfully and show no distortion at any stage of their development.

Records at Manhattan, Kans., indicate that some of the Marquillo hybrids most resistant to the hessian fly are also resistant to the wheat jointworm. A comparison of hessian fly and jointworm infestation records for 146 of these

strains, however, shows no correlation between resistance to the jointworm and resistance to infestation by spring-brood hessian flies.

Severe chinch bug infestations failed to develop during the year, although in some isloated areas barriers were required to prevent migration from small grains to corn. Work to determine the effect on chinch bug populations of eliminating certain varieties of small grains was extended to endemic chinch bug areas in south-central Illinois. The results obtained from these experiments confirm those obtained in other areas and indicate that no benefit in reducing infestation can be derived from eliminating the more favorable small grains during years of high chinch bug populations.

An extensive armyworm outbreak occurred during the year in a number of States, being most severe early in the spring in Mississippi, Arkansas, and Oklahoma, but extending late in the spring to Illinois, Missouri, Kansas, and the more northern States. Observations made on the control of this species indicated that poisoned bran baits without the addition of sawdust, gave the best control. Experiments indicated that cottonseed hulls and alfalfa were fairly good substitutes for bran but required the addition of molasses, which greatly increased their efficiency. Pure wheat-bran baits were highly effective without molasses. Observations made on airplane dusting indicated that successful control could be obtained with calcium arsenate used at the rate of 15 to 30 pounds per acre, but that the cost was much greater than with the use of baits, and the method can be recommended only where materials for baits cannot be readily obtained and where airplane dusting equipment is already available for use on other crops.

Although the habits of the adult corn flea beetle, an important vector of Stewart's disease of corn, are now quite well determined, the biology of its larva in nature is as yet unknown. Work during the year shows that the larva can develop completely on growing bluegrass, oats, rye, and wheat, in addition to corn. In cooperation with the Bureau of Plant Industry, 789 specimens, comprising 15 species of insects from corn, were cultured during the year for the presence of Stewart's disease. No new vector was discovered.

INSECTS ATTACKING FORAGE CROPS

Progeny of alfalfa plants selected for pea aphid resistance have been increased, so a field test of resistant selections of alfalfa was possible in Antelope Valley, Calif. Populations on resistant plants in field-plot tests were less than 2 percent of those occurring on the susceptible field-plot checks and on plants from commercial fields. Highly resistant plants were obtained from three of seven varieties of alfalfa tested for resistance in California.

Surveys discovered previously unknown infestations of the alfalfa weevil in South Dakota, western Nebraska, Colorado, Oregon, Utah, and Wyoming. An investigation has been made to determine what hazards exist in the transportation of alfalfa weevils in baled hay. A method and apparatus were developed which made possible the rapid examination of large quantities of baled hay. The time required for examination of a bale was reduced to about 3 percent of that previously required. Examination of bales of alfalfa hay by this method showed that by midwinter the infestation of stacked, baled hay does not differ essentially from that of cocked, baled hay, although the initial infestation was higher in the former. Results of this investigation show quite definitely that small numbers of weevils survive in, or on, baled hay throughout the winter—one living weevil being found in a bale as late as March 17. Intensive ecological studies conducted in the Grand Valley of western Colorado during the year showed that, in contrast with other districts of the older weevil-infested territory, damage to the first crop developed before the plants were sufficiently mature to cut—thus rendering ineffective the control of the weevil by cutting which has been developed for other areas. It was discovered during the year that in the Grand Valley virtually all female weevils matured in the same year that they became adult and that they laid many eggs before the winter began. This appears to be responsible for the advantage of the weevil over the crop in the spring by permitting nearly all females to resume oviposition with the coming of the first spring warmth instead of their coming gradually into full egg production, as in Utah.

Experiments with sulphur and copper compounds for the control of the potato leafhopper on peanuts, conducted in cooperation with the Virginia Agricultural Experiment Station, have indicated that these materials are not only effective in reducing the leafhopper populations but that they result in a stimulation to the plant which materially increases yields even when no leafhoppers

are present. In 1936 the average increase in yield of field-cured peanuts from treated plots as compared with untreated ranged from 30 to 60 percent. These results confirm those obtained in previous seasons. Although this leafhopper is responsible for considerable loss in the yield of peanuts in Virginia and North Carolina, this increase in yield cannot be attributed solely to reduction in the leafhopper population.

INSECTS ATTACKING SUGARCANE AND RICE

Experiments conducted during the year gave preliminary information indicating that there is a much higher survival of the sugarcane borer in fields in which the cane trash is not burned than in fields in which such trash is destroyed by burning. This higher survival is apparently not compensated for by any increase in parasitization.

It has been found that the green bug is a vector of mosaic disease of sugarcane in Louisiana.

The use of light traps has been found to be a method giving partial control of the sugarcane beetle. Certain varieties of cane were found to be more tolerant to attacks of this beetle than others. Repellents have given excellent results in protecting planted rice from attacks by this beetle.

The West Indian cane fulgorid (*Saccharosydne saccharivora* Westwood) was discovered for the first time in the United States causing heavy injury to some varieties of cane in Florida.

It has been found that infestations of some of the worst insect pests of stored rice begin while the grain is still standing in the field. Rice grown near old stacks of rice straw was found to be 53 percent infested while in the field. In preliminary work borax has been found of value in the control of stored-rice insects. When relatively small quantities are mixed with stored rough rice the development of the insects is prevented, and borax apparently has value in preventing the molding of rice having high moisture content when harvested. Investigations are in progress to determine whether the commercial use of borax in this way is feasible and safe, the size of the dose necessary, and the limits of applicability of the method.

INSECTS ATTACKING STORED GRAIN PRODUCTS

In a study of the distribution of fumigants in vacuum tanks, utilized for the control of insects attacking stored cereal products, it was found that when a tank is filled with merchandise capable of absorbing a fumigant, an equal distribution of the fumigant is not obtained, although theoretically a gaseous mixture when introduced into a nearly perfect vacuum should distribute itself uniformly throughout the tank. An excessive adsorption by the commodity near the gas inlet and adjoining free space occurs, so that by the time the fumigant has penetrated the product it is in a much more dilute form in the places reached last, and an incomplete and uneven distribution of mortality is obtained. It has been found that recirculation of the fumigant in the vacuum vault, for the first 15 minutes of exposure, is sufficient to give even distribution and to produce the maximum effect obtainable by circulating the gas, and that a 25-percent reduction in the dosage is the maximum obtainable by recirculation. It was found impractical to fumigate flour and feeds with ethylene oxide-carbon dioxide mixture under vacuum when the temperature of the material fell below 70° F. At 85° (as in midsummer) these materials can be fumigated with dosages, per 100 pounds of material, of 5 pounds of fumigant for 3 hours, 2 pounds for 6 hours, and 1½ pounds overnight. At 70° a considerable increase in dosage is required. It was found that the susceptibility of insects to fumigants in vacuum fumigation increased as the pressure decreased and that this variation is due to differences in oxygen content of the tank rather than to pressure. The introduction of steam into vacuum tanks when the pressure registered 0.15 inch raised the temperature uniformly throughout both the tank and its contents. A temperature of 122° maintained for 3 minutes under these conditions killed several species of insects buried in wheat in a tank, including the resistant eggs of the confused flour beetle.

Claims have been made that heavier-than-air fumigants, such as chloropicrin and the carbon disulphide-carbon tetrachloride mixture, applied at the surface of grain bins in storage will penetrate effectively to the bottom of the bin. During the year it was shown by experiments, in which containers of insects were buried at each 15-foot level of a 60-foot bin, that these gases did not

penetrate to the 30-foot level and that this method of fumigation is not feasible under the conditions ordinarily encountered.

The minimum lethal dose of hydrogen cyanide, ethylene oxide, chloropicrin, ethylene dichloride, and carbon disulphide for exposures of 1, 3, and 24 hours, at 72° to 76° F., has been determined for the rice weevil, the flour beetle, and the Mediterranean flour moth, and for the eggs of the last two species. In the case of ethylene oxide, the eggs of both the flour beetle and the flour moth are more susceptible to the fumigant with a 24-hour exposure than are their respective adults. With 1- and 3-hour exposures the eggs of the flour beetle are many times more susceptible to the gas than are the adults; the eggs of the flour moth are equally susceptible with the adults for a 1-hour exposure but only slightly more resistant for a 3-hour exposure. Hydrocyanic acid gas is more toxic to the egg of the flour beetle than to the adult at all exposures, whereas the reverse is true regarding the egg and adult of the flour moth. Chloropicrin, carbon dichloride, and ethylene dichloride are in general less toxic to the eggs of the flour beetle and flour moth than to the adults, at all exposures. These results indicate the wide variation in susceptibility to fumigants, not only of different species of insects but of the different stages in their life cycle.

Determination was made of the size and kinds of flour bolting cloth necessary to remove the eggs of the principal insects occurring in finished flour. This information has already been adopted by the trade, and small unit sifters for redressing flour and removing the insects have been developed.

GRASSHOPPERS

The annual grasshopper survey conducted in the fall of 1936 in cooperation with the States indicated that one of the most widespread grasshopper infestations ever known was in prospect and that $2,600,000 for the purchase and transportation of materials would be required to control the infestation. Developments during the spring and early summer of 1937 fully justified this estimate and indicated that the survey had erred on the side of conservatism, particularly in South Dakota and Colorado, where even more severe infestations developed than had been estimated. There was no detailed survey of Texas and New Mexico, where severe infestations also developed.

Congress made $1,000,000 available for grasshopper control late in April. States set up the organization required for cooperation, and shipping of materials for grasshopper bait was begun in May. By the end of June funds available under this appropriation were practically exhausted although bait requirements for the infested areas were far from met, and it was necessary to reduce allotments to States to about half of the estimated requirement. Two factors, however, tended to ameliorate the shortage of Federal bait incurred by the limitation in funds and the unprecedented shortage and high price of bran. The first of these was the adoption of a new formula for bait, developed by research during the previous year, which made it possible to increase the sawdust in the mixture from the 50 percent previously used to 75 percent through the use of bran containing the shorts and middlings. The second was the much greater contribution of materials by States, counties, and individual farmers than in any previous Federal campaign. Some States furnished all the materials required except the poison, and many of them supplied all of the sawdust needed in the mixture.

The development of an extensive outbreak of the long-winged migratory grasshopper in eastern Colorado and northwestern New Mexico created an emergency which prompted the governors of those States to call out the National Guard. In these sparsely settled areas farmers were unable to supply the labor for mixing stations and distribution of bait and the transportation of materials needed to prevent complete loss of crops and a subsequent migration of this truly migratory species into more productive areas of these and adjoining States.

By the end of the fiscal year bait materials had been shipped into Arizona, Arkansas, California, Colorado, Illinois, Iowa, Kansas, Michigan, Minnesota, Missouri, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, Utah, Wisconsin, and Wyoming.

The full results of this campaign cannot be determined until the end of the summer, when an estimate of losses and savings will be available. Generally successful results have been reported where it has been possible to supply sufficient baits and where good crop prospects have encouraged the farmers to consistent control effort.

MORMON CRICKETS

The most general and severe infestation by the Mormon cricket in history occurred during the year. It included parts of Montana, Wyoming, Colorado, Utah, Nevada, Idaho, Oregon, Washington, and small areas in North Dakota and South Dakota. A cooperative control campaign was made possible in Montana, Wyoming, Colorado, Utah, Oregon, and Washington by an allotment of funds from the Works Progress Administration. Labor and most of the necessary supervision were provided under Federal funds. States and counties furnished most of the materials, mixing facilities, and transportation for crews and materials. Control operations were conducted in Idaho and Nevada through independent State Works Progress Administration projects. The most extensive operations were carried on in Montana and Wyoming, where the infestation was most intense and widespread and where it threatened the most extensive cultivated areas. Mixing dry sodium arsenite with lime and applying it with hand or power dusters was the method most generally used for control. This dust was applied to cricket bands migrating to the cultivated areas and was used to clear grainfields of crickets which had hatched there or which had gained access to them through migration. Many miles of galvanized-iron fencing, used effectively as barriers, directed the migrating bands into pits, where they were destroyed. Oiled irrigation canals were used to advantage as barriers to the migration where these were favorably located. Thousands of bushels of crickets were destroyed in this way. Burners and poisoned baits were used to a limited degree but with indifferent results. In areas of most intense infestation all the facilities available were necessary merely to protect crops. At the end of the fiscal year it was evident that to a large degree this object had been accomplished. Losses had been limited to from 10 to 15 percent where a fight was actively waged, whereas otherwise the heavily infested small grains would have been almost entirely destroyed. In some areas the crickets have been completely cleared out of the cultivated crops and the migrating bands have been destroyed for some distance into the hills away from farms. Although the campaign is not yet completed and, as stated, it has necessarily been maintained primarily on a crop-protection basis, there is general agreement that it has resulted in a saving in crops valued at many times the cost of the campaign.

EUROPEAN CORN BORER INSPECTION AND CERTIFICATION

Inspection and certification service to conform with the requirements of the State quarantines of Arizona, California, Colorado, Georgia, Louisiana, Nevada, Oregon, Texas, and Utah continued as previously organized. Following the stationing of Japanese-beetle inspectors in West Virginia and Ohio, the only remaining men working exclusively on European corn borer certification were the inspectors in Detroit and Indianapolis. The bulk of the inspection work was performed by men engaged in both Japanese beetle and European corn borer inspection, and, in the New England area, in gypsy moth certification as well.

This year 19,784 certificates were issued to cover quarantined plant material, principally dahlia tubers, valued at $209,050. This compares inversely with last year's inspections involving issuance of 22,133 certificates to cover material valued at $165,293.

BLACK STEM RUST QUARANTINE ENFORCEMENT

The Federal quarantine relating to black stem rust is designed to prevent the shipping of rust-susceptible species of barberry and *Mahonia* into Colorado, Illinois, Indiana, Iowa, Michigan, Minnesota, Montana, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin, and Wyoming, where the eradication of rust-spreading barberry bushes is carried on. Permits for shipping to these protected States are issued for premises where, as determined by inspection, only rust-resistant species of these plants are grown. During the year such permits were issued to 23 nurserymen and 1 dealer. Transit inspectors intercepted, in the year, 13 shipments that had been consigned in apparent violation of the quarantine.

BARBERRY ERADICATION

For the past 25 years stem rust has caused annual losses in the United States averaging more than $27,000,000. During certain seasons, such as 1916 and 1935, when weather particularly favored the development and spread of the fungus, damage in a single year has exceeded 100,000,000 bushels of grain.

There are two important sources of stem rust inoculum in the northern part of the United States, (1) the remaining rust-susceptible barberry bushes, and (2) rusted grainfields in Texas and Mexico, where the summer stage of the disease survives throughout the year. The relative importance of these sources varies from year to year, depending upon weather and other crop conditions. The first rust found on grains and grasses in the spring is in the immediate vicinity of remaining barberry bushes. In fact, if weather favors the spread of rust, the fungus multiplies rapidly near these inoculum centers, and with continued warm, moist weather the local spreads coalesce early in the season, causing widespread epidemics before the crops mature. Only occasionally during the past 25 years has stem rust, spreading from the South, become epidemic in the spring wheat-growing States in time to do appreciable damage.

Recommended measures for the control of stem rust include (1) eradicating rust-susceptible barberry bushes in important grain-growing States, (2) selecting for seed the more rust-resistant varieties of grain that are otherwise adapted to the area, and (3) planting spring grains early on well-prepared soil.

NINETY-ONE MILLION RUST-SUSCEPTIBLE BARBERRY BUSHES DESTROYED DURING FISCAL YEAR

During the year 91,710,896 barberry bushes were destroyed on 9,417 properties in the 17 States participating in the barberry-eradication program. The expanded program, made possible with allotments of emergency funds, permitted a careful inspection of all native and planted shrubbery on 60,237 square miles in 315 counties. In table 13 are shown, by States, data relating to the progress made in control work during the year. To avoid misinterpreting this information it should be kept in mind that figures in Virginia, West Virginia, and Colorado are hardly comparable with those in other States of the area, as much of the work conducted in these States during the year has been in areas where native species of barberry are prevalent. In the Virginias *Berberis canadensis* is being eradicated in the important grain-growing communities, and in Colorado much of the work was done in the southwestern part of the State where *B. fendleri* is prevalent. In these States native species of barberry grow in patches, often several rods in diameter, which accounts for the relatively large numbers of bushes destroyed.

TABLE 13.—*Progress in barberry eradication during fiscal year 1937*

State	Properties cleared of bushes	Barberry bushes destroyed	Territory surveyed	Security-wage earners		Proportion of all personnel taken from relief rolls
				Maximum employed	Employment	
	Number	*Number*	*Square miles*	*Number*	*Man-hours*	*Percent*
Colorado	57	1,715,456	288	138	136,812.50	95.80
Illinois	547	5,541	7,011	319	288,683.50	92.77
Indiana	203	25,518	4,976	161	140,850.00	91.09
Iowa	541	8,288	9,469	268	228,759.25	91.89
Michigan	1,220	48,996	1,159	452	310,941.50	93.73
Minnesota	558	7,720	5,655	265	336,089.25	91.59
Montana	47	367	875	52	36,044.50	97.21
Nebraska	75	364	8,183	177	107,382.00	92.38
North Dakota	24	604	1,100	110	56,810.50	94.80
Ohio	665	131,285	7,483	303	343,561.33	94.13
South Dakota	6	25	622	32	26,932.50	90.96
Wisconsin	540	15,591	4,143	337	270,763.75	91.73
Wyoming	2	9	173	0	2,614.50	100.00
Total	4,485	1,959,764	51,147	2,614	2,286,255.08	
Missouri	411	2,527	6,782	229	180,718.00	95.34
Pennsylvania	2,227	1,003,494	1,473	303	328,594.25	93.65
Virginia	1,412	52,870,548	457	460	552,092.00	95.17
West Virginia	882	35,874,563	378	390	402,289.25	97.80
Total	4,932	89,751,132	9,090	1,382	1,463,693.50	
Grand total	9,417	91,710,896	60,237	3,996	3,749,948.58	94.50

Since the beginning of the barberry-eradication program in 1918, nearly 24,082,567 bushes (mostly *Berberis vulgaris*) have been destroyed in the 13 States that comprise the original control area, and an additional 124,102,230 bushes have been destroyed in Missouri, Pennsylvania, Virginia, and West Virginia since 1935, when similar work was undertaken in these States.

During the year control work was conducted largely with men obtained through local reemployment offices. After a brief training period they were assigned to field work under the direction of experienced supervisors. Each eradication unit was composed of 5 to 10 men and each supervisor was responsible for 3 to 5 crews.

The field procedure varied with the type of territory in which work was done. In certain counties having a high percentage of the land under cultivation the fence rows, wood lots, and all planted shrubbery were carefully inspected. In wooded areas, including bluffs along rivers and other streams, a single foreman directed as many as 10 to 12 men in a single crew. Under such conditions eradication work was usually begun in known areas of infestation to permit the men to become acquainted with the distinguishing characteristics of the bush, and the strip-scouting method of survey was continued until all territory within 2 miles of the last bush found had been carefully inspected.

As in the past, salt was the principal chemical used for eradication purposes. Chlorates were employed to some extent, particularly for treating native barberries in Colorado, Virginia, and West Virginia. Fuel oils and salt brine were tried experimentally, but a further check of results is necessary before a definite statement can be made as to the relative effectiveness of these materials. Bushes were dug or grubbed only when the application of a chemical might be injurious to nearby shrubs or trees. During the year 5,694 tons of salt and 15,984 pounds of a proprietary weed killer containing sodium chlorate and other ingredients were used.

STEM RUST CAUSED VERY LITTLE DAMAGE IN 1936

In 1936 stem rust caused relatively little damage. There were two principal reasons for this. (1) The uredial stage of the rust was not very abundant in the spring in Texas and Oklahoma, and (2) although barberries remaining in the barberry-eradication area rusted heavily, the abnormally dry weather caused premature ripening of the crops, thus preventing development of the fungus on grains.

Surveys in the fall and winter of 1935 had confirmed previous tentative conclusions that the uredial stage of rust usually becomes established and overwinters more abundantly in the earlier sown fields in Texas and northern Mexico, and occasionally in Oklahoma and Arkansas. Because of dry weather in southern Texas in the fall of 1935, wheat was sown late and did not become generally infected with rust. In northern Texas rust that overwintered in certain early sown fields developed rapidly in the spring of 1936, causing considerable damage in limited areas. While the rainfall in May was above average at certain points in northern Texas, there was not a repetition of the 1935 epidemic, primarily because there was no general distribution of inoculum early in the season. That spores were blown northward late in May is indicated by the presence of early infection in Oklahoma and Kansas. Except in low places and late fields, however, there was no appreciable loss. In northeastern Kansas there was damage in late fields, but the development of the disease in the western part of the State and in most of Nebraska was greatly retarded by the drought.

In general far fewer spores were carried northward by the wind than in 1935, as shown by examination of spore traps exposed at various points throughout the barberry-eradication area.

While there was a tremendous amount of rust on remaining barberries, the attack sometimes being so heavy as practically to defoliate the bushes, local epidemics of rust on grain were restricted largely to States east of the Mississippi River, where moisture was more abundant. Drought and high temperatures in the upper Mississippi River Valley prevented the development of widespread epidemics. Had the weather been normal it is probable that heavy rust would have occurred in many local areas.

The dangerous role of barberries in the production and perpetuation of parasitic races of stem rust (*Puccinia graminis tritici*) is apparent from the following information obtained in 1936: From 151 collections of aecial material

on barberry and uredial material in the immediate proximity of barberry bushes 204 cultures were identified, comprising 24 different races, the ratio of races to collections being about 1:6. From 645 collections of uredial material collected at a distance from barberries 832 cultures were identified. These comprised 14 races, the ratio of races to collections being about 1:46. Several races obtained from barberry are much more virulent on certain varieties of wheat than those obtained away from barberry. There is also further evidence that one of the races of rust most prevalent during recent years (race 56) originated on barberry bushes within the past 10 years.

MORE STEM RUST IN 1937

There was very little evidence of stem rust overwintering in Texas and northern Mexico during the winter of 1936–37. Late in March and in April, however, rust developed rapidly in northern Mexico, and more or less sporadically in Texas, depending upon the amount of rainfall. By May 30 there was from 35 to 50 percent of rust on the winter wheat in the Bosque River Valley and 15 percent in the area north of Dallas.

Winter wheat in northern Oklahoma matured normally, with little damage from stem rust. In eastern Kansas, eastern Nebraska, and western and northern Missouri crops were heavy and succulent, and a week to 10 days late. Weather favored rust, with the result that serious damage occurred, particularly in late fields of the more susceptible soft-wheat varieties. Severe damage to winter wheat has occurred also in western and northern Illinois and central Indiana, with some damage reported from central-western Ohio, southern Wisconsin, southern Minnesota, and southern and eastern South Dakota. Local epidemics of stem rust have developed in the vicinity of barberry bushes in Virginia, West Virginia, and Pennsylvania, with a marked decrease in the amount of damage noted in areas where the eradication of barberry bushes has been largely accomplished.

Stem rust is developing on susceptible varieties of spring wheat in western Minnesota, eastern South Dakota, and eastern North Dakota, and severe damage will most likely occur, particularly in late fields.

SEVENTEEN ADDITIONAL SPECIES OF BARBERRY FOUND SUSCEPTIBLE TO ATTACK BY STEM RUST

Further investigations were conducted to determine the susceptibility of certain species and varieties of barberry advertised in catalogs and trade journals. Those found highly resistant when tested under natural conditions were given further study under controlled (greenhouse) conditions in St. Paul, Minn. More than 150 different species and varieties of *Berberis* have been brought together in the experimental plots at the foreign plant introduction garden at Bell, Md., and others are being added as they are encountered in connection with the nursery-inspection work or advertised for sale.

Inoculations made during the year have proved that the following species and varieties are definitely susceptible to attack by stem rust: *Berberis henryana*, *B. tischleri*, *B. actinacantha*, *B. bullata*, *B. chitria*, *B. concolor*, *B. consimilis*, *B. coralliana*, *B. dasystachya*, *B. farreri*, *B.* hybrids Carmine, Comet, and Coral, *B. macracantha*, *B. poiretii* var., *weichangensis*, *B. rehderiana*, *B. rubrostilla*, *B. vulgaris a flore gracile*, and *B. wilsonae stapfiana*.

When certain species of barberry are found to be highly resistant to the disease, seedlings grown from seed produced on the resistant bushes are tested as a further precaution against releasing, for interstate shipment, a variety or hybrid which, although itself immune, might produce susceptible seedlings.

During the year selected plants belonging to 40 species were inoculated under greenhouse conditions, with the result that 3 additional species, *B. auricoma*, *B. guimpelii*, and *B. parvifolia*, are now definitely classed as susceptible, and 4 species, *B. dictyota*, *B. gracilis*, *B. sanguinolenta*, and *B. pinnata*, have been determined as highly resistant. Further tests will be made, however, before these last are approved for propagation within the protected area.

ACCURATE IDENTIFICATION OF BARBERRY IMPORTANT IN CONNECTION WITH QUARANTINE ENFORCEMENT

The object of Quarantine No. 38 (revised) is to prevent, through education and regulations, the interstate movement (into or between States comprising the protected area) of susceptible species of barberry. In connection with this

work accurate identification of all barberries encountered by Federal quarantine inspectors, State nursery inspectors, and eradication supervisors is extremely important. The taxonomic work is carried on at the Arnold Arboretum, Jamaica Plain, Mass., where the best facilities are available. As previously indicated, the genus *Berberis* contains a great many species, varieties, and hybrids, and, further to complicate field work, many of the species and variety names in common use are synonyms.

During 1936 more than 200 *Berberis* and *Mahonia* specimens were submitted to the Bureau for identification by field inspectors and property owners. In addition, some 200 questionable bushes were identified in the field. During the year the key used in classifying barberry specimens was enlarged to include more than 230 species, varieties, and hybrids.

Records show that during 1936 22 nurseries applied for permits to ship immune barberries into and between States protected by the Federal quarantine. Prior to granting this authority, 4,740 acres of nursery stock were inspected with the result that 137 rust-susceptible barberries were destroyed. Twenty-one nurserymen were authorized to ship immune species of barberry interstate and one nurseryman was given a dealer's permit for the same purpose. In addition to the bushes destroyed in nurseries, the Federal nursery inspector, in cooperation with State nursery inspectors and State leaders of barberry eradication, removed 950 susceptible barberries from parks, arboretums, and private grounds within the barberry-eradication area.

BARBERRY ERADICATION AIDED BY INFORMATIONAL ACTIVITIES

During 1936 the steadily increasing demands for information relating to the control of stem rust of cereals were met by (1) releasing approved magazine articles, (2) giving illustrated talks before school and adult groups, (3) placing demonstrations at seed shows and local fairs, (4) distributing brief circulars in advance of field operations, and (5) carrying on a cooperative educational program with public schools. The twofold purpose of the educational work is to stimulate property owners to keep their farms free of rust-susceptible barberry bushes once the initial eradication work has been completed, and to encourage the reporting of badly rusted grainfields or areas known to be infested with barberry bushes as a guide to communities in which survey work is urgently needed.

Table 14 summarizes results of informational work conducted during the period 1928 to 1937. Many elementary and high schools throughout the north-central part of the United States are now including the study of stem rust as a part of the regular course work in agriculture or general science.

TABLE 14.—*Summary of results of informational work, by States, July 1, 1928, to June 30, 1937*

State	Counties completed	Demonstrations given			Total attendance	Total properties reported	Total bushes reported
		Grade schools	All schools	Schools and other organizations			
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Colorado	22	852	1,013	1,018	31,853	35	307
Illinois	20	2,348	2,485	2,540	57,562	355	464
Indiana	33	1,021	1,699	1,764	134,211	159	795
Iowa	35	4,041	4,761	4,879	477,989	886	82,040
Michigan	25	2,945	3,322	3,383	893,401	799	7,197
Minnesota	35	3,911	4,232	4,747	183,816	570	3,450
Missouri	0	0	0	5	955	0	0
Montana	27	1,971	2,067	2,075	54,314	37	115
Nebraska	24	2,116	2,275	2,321	51,425	102	1,439
North Dakota	22	3,425	3,727	3,749	89,077	27	222
Ohio	8	419	530	552	23,184	123	2,813
South Dakota	18	1,701	1,885	1,965	82,392	42	115
Wisconsin	2	286	300	318	7,527	109	279
Wyoming	9	446	494	505	11,488	10	49
Total	280	25,482	28,790	29,821	2,099,194	3,254	99,285

TRUCK CROP AND GARDEN INSECT INVESTIGATIONS

WIREWORMS

Investigations on the biology and control of wireworms (*Limonius californicus* Mann. and *L. canus* Lec.) which infest the irrigated lands of the West have been continued in California, Washington, and Idaho, emphasis being placed on testing soil fumigations with naphthalene and dichloroethyl ether, soil-surface applications of sulphur in an attempt to prevent or reduce egg deposition by wireworm adults, and the effect of crop rotations on wireworm infestations.

It was found that the damage caused by wireworms to onions could be decreased greatly by the incorporation into the soil of 800 pounds of crude naphthalene per acre, while the land was being plowed, and during a time when soil temperatures were 70° F. or higher. Although best results have been obtained with naphthalene fumigation of the soil when the temperatures reach 70° or higher, experiments performed in the State of Washington indicated that worth-while results may be obtained with naphthalene even when the soil temperature to a depth of 12 inches ranges from 65° to 67°. Comparative tests with several other fumigants showed that crude naphthalene at the rate of 800 pounds to the acre was more effective and cheaper than either calcium cyanide at the rate of 400 pounds to the acre or a commercially prepared fumigant consisting principally of crude naphthalene and silica at the rate of 22 parts of the former to 78 parts of the latter. In these tests crude naphthalene killed approximately 92 percent of the wireworms, calcium cyanide killed approximately 78 percent, and the commercially prepared soil fumigant killed 68 percent.

In California dilute solutions of dichloroethyl ether at a concentration of 5 cc of this material in 1 gallon of water were found to be highly toxic to wireworms when drilled into rows of beans used to attract and concentrate the pests. Tests on plant growth demonstrated that at concentrations of 1, 3, and 6 cc respectively, per gallon of water, this material caused no apparent injury to growing lima beans. Higher concentrations caused plant injury. Evidence was also obtained that applications of dilute solutions of this material of sufficient strength to be effective against wireworms will not injure tomatoes, potatoes, cabbages, and corn. Before such treatment is advocated as a general practice, however, further experimentation is necessary.

Field-plot tests in the State of Washington indicated that the soil-surface application of sulphur at rates of 400 and 800 pounds per acre, respectively, did not have any appreciable effectiveness in preventing egg deposition by the adults of either the sugar-beet wireworm or the Pacific coast wireworm.

The late planting of potatoes in the irrigated section of the Pacific Northwest where wireworms are abundant offers a means of escaping maximum injury by these pests. In Washington during the season of 1936, an average of 57 percent of the potatoes planted on April 7 and harvested during the period from August 10 to 17 were injured by wireworms, whereas in comparable plantings made on June 23 and harvested early in November an average of approximately 44 percent of the tubers showed wireworm injury. Actually the difference in relative wireworm injury suffered by early planted and late planted potatoes was less in 1936 than during previous years because conditions during that year were such that the wireworms did not begin their seasonal migration downward until a later date than normal.

Crop-rotation studies continue to bear out the information previously gained that wireworm abundance increases rapidly in fields planted to red clover and sweetclover, that the rate of increase is retarded in fields planted to truck crops, and that practically no increase of these pests occurs when alfalfa or pasture grasses are grown.

Field studies on the Gulf wireworm in Alabama showed definitely that there was a difference in the number of wireworms found in land planted year after year in potatoes as compared with the number occurring in new ground and in old field sod. The wireworms were less abundant in fields where suitable crop rotation was practiced and in cotton fields than in fields where potatoes were planted year after year. It has been demonstrated that while the trapping of adults under crop remnants raked into windrows followed by the burning of such windrows destroyed a high percentage of adults, this method was not effective unless the soil so treated was cleaned thoroughly of plant remnants and the soil surface leveled off. Soil fumigation with crude naphthalene, following the methods and dosages used successfully against wireworms in the Pacific Northwest, was not successful in combating mixed populations of the Gulf wireworm and the sand wireworm in experimental field tests performed at

Charleston, S. C., The wireworm populations were not reduced significantly in these tests, nor was there any significant difference in the number and weight of tubers showing wireworm injury which were produced in the treated plots and of those from the untreated plots.

BEAN AND PEA INSECTS

Field experiments with insecticides in Ohio and Virginia on beans grown for the green-bean market or for canning have shown definitely that the Mexican bean beetle can be controlled best at a minimum cost with sprays or dusts of cube or derris. Results with cryolite sprays or dusts have continued to indicate that the control value of this material is questionable, although it gave a fair degree of control under some conditions. In the East the performance of cryolite apparently varies to a certain extent from year to year in accordance with variations in weather conditions and possibly in the composition of the insecticide. In Colorado the results from tests on irrigated beans grown for the dry-bean market demonstrated that, based on increased yields and calculated financial returns, cryolite spray gave the most efficient control and was significantly better than zinc arsenite spray, a material commonly employed in that territory. Sprays and dusts containing rotenone were also effective against the bean beetle in the West, but they cost more than the cryolite spray. Since wide publicity had been given to an article which indicated that magnesium sulphate (Epsom salt) used as a spray in the proper concentration constituted an effective control of the Mexican bean beetle, experiments with this material were resumed in the spring of 1937, even though tests conducted in Ohio during 1928 had demonstrated that this material was not toxic to the Mexican bean beetle. Laboratory tests with Mexican bean beetle larvae, using dosages of Epsom salt 100 times as great as the lethal dosage of calcium arsenate, showed that the test larvae fed on the treated bean foliage, that they consumed as much leaf area as the larvae placed on untreated foliage, that they molted successfully, and that there was no resulting mortality which could be attributed to Epsom salt. Since laboratory studies during 1936 disclosed that the active ingredients of derris were translocated in treated plants in such a manner as to prevent extensive feeding of the Mexican bean beetle on foliage that developed on the plants after the insecticide had been applied, it was decided to ascertain the residual effect of derris on bean foliage in various widely separated localities in the United States where wide variations in temperature, humidity, and intensity of sunlight occurred. Bean plantings were made for this purpose at New Haven, Conn., Norfolk, Va., Columbus, Ohio, Baton Rouge, La., Madison, Wis., Manhattan, Kans., Grand Junction, Colo., Twin Falls, Idaho, Ventura, Calif., Corvallis, Oreg., Puyallup, Wash., and Phoenix, Ariz. These plantings were treated with a derris spray, and samples of leaves were taken at given intervals and sent to Columbus, Ohio, for analysis. In every case, rotenone was recovered in sufficient quantities at the expiration of 2 weeks after treatment to be indicated by the colorimetric method and goldfish test. At Madison, Wis., Grand Junction, Colo., Twin Falls, Idaho, Corvallis, Wash., and Columbus, Ohio, derris showed a slower loss of toxicity than at the other laboratories. Neither the intensity of sunlight nor high humidity alone appeared to affect significantly the decomposition rate. At Phoenix, Ariz., where daily temperatures averaged 100° F. during the period of the test, rotenone was recovered after 10 days. At Ventura, Calif., where no rain fell during the test, all of the toxicity had disappeared at the end of 4 weeks. In general, these tests demonstrated that the residual properties of derris were such that in any part of the United States where cultivated plants are commonly grown this insecticide could be used effectively against the species of insects which it is known to affect.

Dust mixtures containing rotenone gave excellent control of the pea weevil in large-scale field tests performed in Idaho, Washington, and Oregon. In Oregon 60 fields, involving approximately 300 acres of peas grown for canning, were included in the tests. The greater part of this acreage was treated with a dust mixture containing 0.75 percent of rotenone with talc as the diluent. This combination appeared to be more effective than dust mixtures containing 0.25, 0.50, and 0.75 percent of rotenone, respectively, with diatomaceous earth as the diluent. Two applications of these dust mixtures were made to all of the fields with specially constructed power dusters. Based upon an examination of the peas at the viner, the control achieved in the treated fields averaged approximately 97.7 percent. In the Washington canning-pea section many tons of rotenone dust mixtures were applied to the weevil-infested sections of pea

fields, more particularly to the strips from 25 to 30 feet in width around the edges of the fields, where the hibernating weevils had congregated. Under favorable weather conditions the majority of the infestations in the treated fields were reduced more than 95 percent and in some instances the weevil population was reduced 99 percent or more. From one to three applications were made to these field borders, depending upon the magnitude of the movement of the weevils into the fields after such fields were dusted. The cost of this method of control to determine its true economic value has not been worked out as yet. Additional work on the border trap-crop method of control indicated that large numbers of pea weevils can be concentrated in the early planted strips, where they can be killed by plowing under deeply and cleanly, but that this method cannot be depended upon to control the weevil, since the seasonal period of emergence of the weevil from hibernation may vary from year to year, thus reducing the effectiveness of the border trap crop. In tests conducted with several different types of tillage equipment it was shown that the deep plowing under of shattered peas on the soil surface with a moldboard plow equipped with proper covering attachments prevented a large number of the weevils contained in such peas from emerging to the soil surface. Imported parasites (*Triaspis thoracicus* (Curtis)) of the pea weevil, comprising approximately 21,000 living parasite adults, were released in Idaho, but no definite results were obtained on this phase up to the close of the year. Biological studies disclosed that in Idaho the pea weevil was able to survive minimum temperatures of −16° F. but was not able to survive a minimum of −30°, thus indicating a climatic limitation of its distribution as an economic pest. It was determined that the percentage of mortality of the overwintering weevils was directly proportional to the degree of protection afforded by snow or other covering during periods of low temperature.

The pea aphid continued to cause heavy loss to the pea growers in many of the major pea-producing sections of the country, particularly in Maryland, Wisconsin, western New York, and Ohio. From the data accumulated during the past two seasons the outlook for a successful control of this long-standing pest with rotenone-bearing materials is promising. Particularly good results were obtained with a derris or cube dust mixture containing a specially prepared spreading agent, such a dust being prepared by atomizing a sodium oleyl alcohol sulphate into the derris or cube dust mixture while it was being revolved in a dust mixer. Field tests with derris and cube sprays or dusts demonstrated that the aphid mortality progressed over a period of time, ranging from a week to 10 days or longer, after the treatments were applied and that the infestation in the blossom clusters and in the growing tips of the pea vines was reduced to a greater extent than it was on the entire plants. This latter development is important, since the damage to the blossom clusters and to the growing tips of the plants has a pronounced effect on the yield of the peas. Analysis of canned peas from plants that had been treated by dusting or spraying with derris at the dilutions found to be effective in the control of the pea aphid showed that no trace of derris constituents could be detected in any of the peas that had been removed from the treated plants. The time of application of the treatment also appears to be a very important factor in the economic control of the pea aphid, and this important phase of the problem remains to be developed for all affected areas.

Field experiments in eastern Virginia, in an attempt to determine the relative effectiveness of various insecticides for the control of the corn earworm on lima beans, disclosed that the best control was obtained with cryolite dusts or sprays. In the dust form the cryolite was applied either as an undiluted dust or at the rate of 60 parts of cryolite and 40 parts of talc or sulphur. In the spray form the cryolite was used at the rate of 3 pounds to 50 gallons of water. In addition to reducing the number of wormy pods as compared to those produced on untreated plots, applications of cryolite dusts and sprays increased the total number of pods produced. Phenothiazine gave good protection against corn earworm injury but failed to show a significant increase in the number of pods produced as compared to the untreated plants. Negative results were obtained with various dust mixtures of derris, cube, pyrethrum, nicotine, and sulphur. The Division of Insecticide Investigations of this Bureau made analyses of samples of shelled and unshelled lima beans from plots that had been treated with cryolite and found that the fluorine residue remaining on the unshelled beans (pods) was in many instances above the tolerance established for fluorine on fruit (0.01 grain per pound). Analysis of the shelled beans, however, showed in most instances that the quantity of fluorine on such beans was well below 0.01 grain per pound. Analyses were also made of canned beans from cryolite-

treated plants that had been run through the commercial process of vining and canning. The result of the analysis of this product indicated that when lima beans are treated as described above and run through the ordinary washing process, the canned product is free from harmful fluorine residues. Since lima beans are shelled before being consumed, it appears that cryolite may be applied safely for the control of the corn earworm on this crop.

TOMATO INSECTS

Although the tomato pinworm has continued to cause serious losses in southern California, good progress has been made on biological and control studies. Results of field-plot tests have indicated that a cuprous cyanide dust mixture with talc as the diluent (1 to 5), cuprous cyanide used as a spray at the rate of 3 pounds to 100 gallons of water, and natural cryolite diluted with talc and diatomaceous earth reduce infestations of this pest from 67 to 80 percent, based upon the percentage of noninfested fruit produced on the treated as compared to the untreated plots. Negative or poor results were obtained with sprays containing an organic thiocyanate, cryolite, calcium arsenate, nicotine sulphate and a light oil-pyrethrum extract combination, and phenothiazine, as well as with dust mixtures containing pyrethrum, calcium arsenate, and phenothiazine. Observations on the habits of the insect show that the tomato pinworm adult favors the lower surface of the tomato leaf for egg laying. These studies indicated that 57.4 percent of the eggs were deposited on the lower surface of the leaf, 40.8 percent on the upper surface, and the remainder on the petioles. Field records show that approximately 91 percent of the pinworm-infested leaves were folded on the upper surface, which indicates the necessity of applying insecticides, if any are found satisfactory, so as to cover thoroughly the under surfaces of the leaves. Examinations in fields heavily infested by the tomato pinworm have indicated that approximately 80 percent of the larvae pupate in the top half-inch layer of soil and that approximately 98 percent of them pupate in the first inch of soil. It is apparent that the tendency of the tomato pinworm larvae to pupate very close to the soil surface may render it possible to develop some measure of control of these pests through the medium of cultural practices designed to disturb or destroy the pupal cells during critical periods. The ability of the tomato pinworm to survive under adverse conditions was demonstrated during the winter of 1936–37 when a very high percentage of survival occurred in southern California even though the longest cold spell on record prevailed in this area during January 1937, including a minimum of 22° F. and a total of 17 nights during which the temperatures at Alhambra, Calif., fell below freezing.

During the year the work on tomato fruitworm (*Heliothis obsoleta* F.) was expanded, and particular attention was given to the habits of the pest as well as to control tests. Dust mixtures containing calcium arsenate, cryolite, or cuprous cyanide have given best results in experimental plots, although none of these gave an entirely satisfactory measure of control. Derris, pyrethrum, and phenothiazine have given poor results. The importance of combating the tomato fruitworm in its early stages was substantiated by the results of laboratory experiments in California wherein it was shown that each larva of the fruitworm is capable of injuring or destroying six tomato fruits, on an average, during its larval period. The number of tomato fruits destroyed by each larva under observation ranged from 4 to 10. These studies also demonstrated conclusively that the young larvae are migratory in their habits and travel commonly from fruit to fruit during their period of larval activity. Cage studies in Utah indicated that the tomato fruitworm was unable to survive the winter of 1936–37 in that locality even though the individuals kept under observation were placed in cages under very favorable conditions during the fall of 1936 and supplied with sufficient food to enable them to reach maturity before entering the soil.

MISCELLANEOUS VEGETABLE INSECTS

Additional experimental work has shown that paradichlorobenzene is effective against larvae, pupae, and adults of the sweetpotato weevil when used to fumigate seed sweetpotatoes in banks and barrels. Preliminary experiments have indicated that the eggs of the sweetpotato weevil may be killed also during the process of paradichlorobenzene fumigation in barrels. The grade of material used and the temperatures during the fumigation period are important factors in successful fumigation. It was shown that fumigation with this material did not injure the seed or reduce plant production. Biological investigations demonstrated that the adults of the sweetpotato weevil are able to fly for a distance of at least 400 yards.

Laboratory toxicity studies on the vegetable weevil demonstrated that pyrethrum diluted with equal parts of china clay compared favorably in toxicity with undiluted calcium arsenate, but that both of these were distinctly superior to derris combinations containing 0.5, 1.0, and 2.0 percent of rotenone, respectively, and to sulphur. In field experiments directed against the turnip aphid on turnips and mustard, however, it was shown incidentally that dust mixtures containing 1 percent of rotenone, with equal parts (by weight) of finely ground dusting sulphur and tobacco dust as the diluent, and derris sprays containing approximately 0.02 percent of rotenone, with or without an alkylphenylbenzenesulphonic acid spreader and wetting agent, were effective in protecting the turnips and mustard from damage by larvae of the vegetable weevil. These insecticidal applications were begun when the plants and the infesting weevil larvae were small. They were repeated at intervals of 14 days, from four to six treatments being applied. Judging from these experiments it appears that rotenone compounds may be effective when applied to plants infested with small vegetable weevil larvae.

Observations in California upon the effect of eradicating nightshade, the overwintering host of the pepper weevil, as a control measure for this insect demonstrated that under favorable conditions this method leads to a marked reduction in infestation. Tests with several insecticides not tried previously against the pepper weevil demonstrated that phenothiazine, dibenzothiaphene, and commercially prepared combinations of pyrethrum were not as effective as calcium arsenate against the insect. Observations of commercial operations indicated that treatments of calcium arsenate applied at the proper time and in the proper manner gave commercial control of the weevil and that the latest developed washers were effective in removing the excess arsenical residues from peppers before they were dried or directly after harvest.

Investigations on mole crickets (*Scapteriscus* spp.) under Florida conditions have disclosed that their principal food consists of organic matter present in the soil, instead of living plant tissue as formerly supposed, that fresh baits are preferred to decomposed baits, that paris green in baits is definitely repellent, and that sodium fluosilicate in baits is not definitely repellent. Control experiments have also demonstrated the ineffectiveness of magnesium sulphate (Epsom salt) in baits.

A study of the seasonal occurrence in the Salt River Valley, Ariz., of several species of loopers (*Autographa* spp.), the beet armyworm, and cutworms injuring lettuce disclosed that these depredating worms do not undergo any distinct hibernating period in this territory and that all stages of these insects may be found during the year. The cool winter weather, however, retards the activities of these worms to such an extent that it usually has a distinct bearing on control measures. Fall-grown lettuce develops very rapidly, and the results of experiments with this crop indicated that one application of insecticides containing arsenicals, when the plants were small, protected such plants until they had established themselves sufficiently to overcome the attacks of the worms. Experiments in small field plots demonstrated that the organic insecticides derris and pyrethrum, applied after the lettuce had been thinned, would control the loopers but would not control the beet armyworm or cutworms.

An improvement in hand methods of parasitization of the European earwig rendered it possible to parasitize earwigs 10 times faster than heretofore, thus making available a large number of parasites (*Bigonichcta setipennis* Fall.) for reinforcing existing colonies and starting new ones. Recovery operations indicated that the parasites had spread to a distance of at least four blocks in the case of colonies liberated in the city, and to a distance of three-fourths of a mile in the case of parasites liberated in the country. In field experiments with poisoned baits for the earwig it was determined that bait containing salt in place of fish oil was not so effective as the standard bait, that bait containing sodium fluoride was almost as effective as the sodium silicofluoride used in the standard bait, and that bait containing one-half the customary dosage of sodium silicofluoride was unsatisfactory.

COLE CROP INSECTS

Investigations on cabbageworms attacking cabbage in Louisiana and South Carolina yielded definite progress in the formulation of a control program. It was found, in the instance of the spring crop of cabbage, that timely applications of a derris dust mixture containing 0.5 percent of rotenone protected the crop adequately against the common species of cabbageworms (*Autographa brassicae* Riley, *Ascia rapae* L., and *Plutella maculipennis* Curt.). Results

indicated that such applications were applied to best advantage economically during the period between the heading of the cabbage and harvest, or during the harvest period when harvest was prolonged and conditions were suitable for insect development.

In field studies to determine the economic status of the more common species of cabbageworms attacking cabbage in Louisiana and South Carolina it was found that, on an average, 41 percent of the cabbage plants failed to make marketable heads (U. S. Grade No. 1) owing to cabbageworm injury, that an additional 23 percent failed to mature owing to causes other than worm injury, and that the remaining 36 percent produced marketable cabbage. In about half of the fields under observation the growers had applied derris dust mixtures, or paris green or lead arsenate, as well as poisoned bait for cutworms. In those fields where control measures had been practiced 30 percent of the potentially marketable cabbage plants were rendered unmarketable by worms, as compared to 74 percent in the fields where no control measures were used, thus indicating the possibilities of improved yields by insecticide applications. In this same series of studies it was shown that, under the conditions existing when these observations were made, the cabbage looper and the imported cabbageworm caused approximately an equal degree of damage, per worm, and that either species will cause about four times as much damage as an equal number of the larvae of the diamondback moth. If this relative importance of the three more important species of cabbageworms is found to persist from year to year, the importance of emphasizing the control of the two first-named species is evident.

When the physical characters of individual cabbage plants that may affect the degree of cabbageworm infestation and injury were being studied, it was indicated that such characters as undulation, bloom, and color are apparently not important but that the type of plant within varieties may exert a decided effect in attracting the moths for deposition of eggs and in the subsequent growth and survival of the resulting larvae.

Investigations of the cabbage webworm in North Carolina demonstrated that the most serious injury by this insect occurred during the seedling and transplanting stages of the host plant. Applications of undiluted calcium arsenate or of dust mixtures containing 0.5 percent of rotenone during this period of growth gave promising indications of control. The cabbage webworm failed to survive the winter of 1936–37 in North Carolina, even in the presence of unusually mild conditions.

BERRY INSECTS

Results of insecticide tests against the raspberry fruitworm in the Puyallup Valley, Wash., showed that dust mixtures containing 0.5 percent of rotenone and sprays containing 0.01 percent of rotenone were effective as a control and did not leave a harmful residue on the marketed berries; that while phenothiazine gave the best degree of fruitworm control, it injured the plants to such an extent that the yield was decreased greatly; that the use of arsenical sprays or dusts after any of the blossoms have opened may leave a poisonous residue above the tolerance limit on harvested fruit; and that late applications of insecticides gave the best control.

Continued experiments in the control of the red berry mite (*Eriophyes essigi* Hassan) in the Puyallup Valley demonstrated that the application of lime-sulphur sprays during the dormant period of the plant, followed by sprays containing wettable sulphur or emulsions of refined petroleum or coal-tar oil during the growth of the plants and up to the time when the fruit begins to ripen, results in an adequate control of this mite.

BEET LEAFHOPPER

Investigations of the beet leafhopper in the intermountain region of Colorado, Utah, Idaho, and Arizona resulted in the addition of important information respecting the critical breeding areas of this insect. Migration of this pest was traced definitely from southern Arizona breeding areas to the western Colorado beet fields. In field experiments, conducted in cooperation with beet-seed producers, pyrethrum-oil sprays directed against the beet leafhopper on sugar beets grown for seed in Arizona indicated that beneficial results were obtained from this treatment as judged by an increased yield of seed per acre. Extensive field observations indicated that the delayed planting of beans in southern Idaho decreased the severity of curly top disease, which is transmitted by the beet leafhopper. In a study of factors governing curly top in-

fection, made in south-central Idaho during the 7-year period 1930–36, it was concluded that early spring movements of the beet leafhopper were followed by rapid and widespread curly top infection, resulting in low yields of sugar beets, whereas late spring movements were followed by seasons in which sugar beets escaped serious curly top infection and produced good average yields. A comparison of the acreages of sugar beets planted, thinned, abandoned, and harvested, and the resultant yields per acre, during seasons of high curly top infection, with those of low infection, showed that much abandonment of sugar-beet acreage occurred during those years when the curly top disease appeared early in the season and spread rapidly, and that low tonnages of beets resulted, whereas very little abandonment occurred in years when curly top infection was late and slow in spreading, and that good average yields were obtained under these conditions. In comparing the average yields of sugar beets in 1935, during which resistant strains of beets were planted, with the yields obtained in 1930 and 1932, during which susceptible strains were grown, it was shown that high curly top infection reduced the average yield of susceptible beets in 1930 to a point below the margin of profit, and that low curly top infection allowed the production of a highly satisfactory average yield in the same strains of sugar beets in 1932; also, that the resistant strains of sugar beets produced a good average yield in 1935, despite a high infection early in the season.

As a result of a survey made in Texas, approximately 2,700 square miles of territory were added to the known breeding areas of the beet leafhopper. Leafhoppers from this area have been primarily responsible for the curly top disease epidemics which have been prevalent in the spinach fields of Texas. The known breeding areas of the beet leafhopper in this section now occupy approximately 10,700 square miles north of the Rio Grande in New Mexico and Texas in addition to the unknown extent of adjacent areas in Mexico.

Field observations in California indicated that the curly top disease, of which the beet leafhopper is the vector, is more prevalent in tomatoes planted in sandy soils than in those planted in soils of the heavier types, and that fields of tomatoes planted before the spring migration of the leafhoppers were infected by curly top to a greater extent than those planted after the principal leafhopper migration. Biological investigations disclosed that the beet leafhopper can exist for long periods late in the fall on various species of deciduous trees grown in or adjacent to the San Joaquin Valley, in addition to the previously known host plants of this insect. High populations of the beet leafhopper which occurred during the fall of 1936 on Russian-thistle growing adjacent to the winter breeding grounds of the insect necessitated the spraying of large areas of this weed to destroy the leafhoppers congregated thereon.

TOBACCO INSECTS

Extensive field-plot tests against tobacco flea beetles (*Epitrix parvula* F. and *E. cucumeris* Harr.) in Florida, Tennessee, North Carolina, South Carolina, and Connecticut indicated that these pests could be controlled in the plant bed, as well as on newly set plants and on the growing crop, by timely applications of dust mixtures containing rotenone derived from derris or cube, with sterilized tobacco dust as the diluent. In the wrapper-tobacco districts of Connecticut and Florida the growers have adopted dusting with cube or derris mixtures for flea beetle control, but in the fine-cured and other sun-grown tobacco areas these insecticides are not as yet recommended for general use. From data obtained to date, dust mixtures containing rotenone gave a higher initial degree of control than insecticides containing arsenical or fluorine compounds. In a series of experiments designed to show the relative toxicity of cube dust mixtures containing 0.5, 1.0, and 1.5 percent of rotenone, respectively, against the tobacco flea beetle on shade-grown tobacco in Florida, it was shown that the dust mixtures containing 1.0 and 1.5 percent of rotenone, respectively, were much more toxic and gave a higher degree of control of the flea beetles than the dust mixtures which contained 0.5 percent of rotenone. These conclusions were reached as a result of a detailed study of the harvested product, in which it was shown that the percentages of injured leaves, together with the percentages of the commercial gradings, served as a satisfactory method for obtaining a relative comparison of the effect of the different dilutions used. Incidentally, these studies demonstrated that a flea beetle infestation of only moderate intensity may cause a loss, based on an average crop return in cigar-wrapper tobacco, which reaches $475 per acre.

Laboratory studies to determine the comparative toxicity of certain arsenicals and nonarsenical compounds to the larvae of tobacco hornworms (*Protoparce*

spp.) showed that none of the arsenicals now available were more toxic than the paris green-hydrated lime dust mixture which is now advocated for combating these insects. A satisfactory substitute for paris green and other arsenicals has not been found among the organic compounds tested.

Experiments in tobacco warehouses of the closed type in Virginia showed that dusting with pyrethrum was a very effective method of combating the adults of the tobacco moth. A reduction of approximately 97.5 percent in the population of this insect was obtained in warehouses where this method of control was utilized.

GREENHOUSE AND BULB INSECTS

During 1936 it was found that gladiolus corms infested by the gladiolus thrips lost weight during the storage period faster than noninfested corms, and that, after planting, the infested corms were retarded and made an uneven growth; also, that the blooming of such corms was delayed and subsequent corm production reduced greatly as compared with noninfested corms. Although many different spray combinations were tested against the gladiolus thrips, the arsenical-brown sugar combinations gave the best degree of control. With the possible exception of lead arsenate, however, such combinations burned the foliage rather severely.

Observations at Charleston, S. C., on the insect vectors of the azalea flower spot disease revealed that insects did not bring the organism causing this disease into gardens or nurseries to cause infection on the flowers appearing early in the season. The appearance of the earliest infections on flowers close to the ground indicated that the soil or mulch may be the hold-over source between flowering seasons. It was found that with the increase in the number of insects that visited azalea flowers, notably several species of bees (*Bombus* spp.), a decided increase occurred in the local spread of the disease on all parts of the azalea plants. The percentage of infective insects increased in the daily collections as the disease became more prevalent. Evidence was obtained that insects could carry azalea flower spot infection for a distance ranging from 1 to 5 miles.

A high percentage of the common red spiders were killed on greenhouse-grown lima beans and sweetclover by spraying with an organic thiocyanate applied under 300 pounds of pressure. Similar results were obtained by dipping strawberry plants infested by the red spider in an organic thiocyanate spray mixture or in a water suspension of derris.

MUSHROOM INSECTS AND MITES

Tests made against various species of mushroom flies (*Sciara* spp.) and other pests in the mushroom houses at Beltsville, Md., demonstrated that free nicotine (40 percent) in water at dilutions of 1 to 100 and 1 to 200 (containing 0.4 and 0.2 percent of free nicotine, respectively), applied as a drench to the mushroom beds at the rate of 100 cc per square foot, gave a promising degree of control of the flies and other pests and caused a marked increase in the production on the beds receiving this treatment. Beds treated at 4-day intervals with a total of five or six treatments yielded approximately one-third more mushrooms than those treated at 8-day intervals and gave approximately twice the yield of the untreated beds. Analysis of the mushrooms treated with the free nicotine solutions showed that the highest nicotine content of any sample was 29 parts per million by weight, a quantity not believed to be harmful to the consumer. Paradichlorobenzene, when used as a fumigant at the rate of 1 pound per 1,000 cubic feet of air space for an exposure period of 48 hours, gave good control of sowbugs but did not control mites (*Tyroglyphus* spp.) or springtails (*Lepidocyrtus* spp. and *Achorutes* spp.). Taxonomic studies indicated that the most common species of mushroom mite in the United States may be a different species than was formerly recorded.

COTTON INSECT INVESTIGATIONS

In February 1937 the station at Tlahualilo, Durango, Mexico, was discontinued. This station was established before there was opportunity to conduct pink bollworm investigations in the United States, but since these investigations may now be conducted in the vicinity of Presidio, Tex., where this Bureau has a station, the special need for a station in Mexico no longer exists.

During the spring of 1937 investigations were begun at five new seasonal field stations. Investigations of boll weevil control on sea-island cotton were started in Alachua County, Fla., in cooperation with the Florida Agricultural Experiment Station, in McIntosh County, Ga., in cooperation with the State

entomologist of Georgia, and in Echols County, Ga., in cooperation with the Georgia Coastal Plain Experiment Station. In Arizona, in cooperation with the Arizona Agricultural Experiment Station, studies were begun at Mesa and Yuma on the control of hemipterous insects. For the work at Yuma, headquarters were established at the Bureau of Plant Industry field station at Bard, Calif.

BOLL WEEVIL

The year 1936 was notable because of the comparatively small damage caused by the boll weevil, the losses by this insect being less than during any year since 1925. This unusual condition was caused by the low boll weevil population entering hibernation in the fall of 1935, by the low temperatures that caused high mortality among the hibernating weevils during the winter, and by the high temperatures and drought conditions during the 1936 growing season in the States east of Texas. The weevil caused its greatest damage in Texas. In eastern and southern Texas there was a higher survival of weevils in the spring of 1936; weather conditions were favorable for their development throughout the season, and for the first time in many years the weevils caused a greater reduction in yield per acre in Texas than in any other State. The low winter temperatures caused the lowest survival in 1936 ever recorded in the hibernation cages at Florence, S. C., and no survival in the cages at Eufaula, Okla. The survival of weevils was much lower than normal at Tallulah, La., but at College Station, Tex., it was several times higher in 1936 than usual. The generally low survival over most of the Cotton Belt was followed by a very dry spring, with extremely high temperatures in May and June, which further reduced the number of weevils, except in eastern Texas. The drought was more prolonged in Oklahoma, where only 2.11 inches of rain fell in the 99 days from June 8 to September 14, 1936, and the weevil infestation was practically wiped out. At Tallulah, La., approximately 90 percent of the grubs in the infested squares were killed by climatic conditions during the latter part of June. As a result of the low survival and climatic control, the infestation did not build up until late in the season, and in many sections no control measures were necessary. This low weevil population over most of the Cotton Belt was followed by an early and widespread infestation of leaf worms, which defoliated the cotton early and further reduced the weevil population that entered hibernation in the fall of 1936.

The winter of 1936–37 was mild, and in the boll weevil hibernation experiments at Florence, S. C., the survival was much higher than during any spring since 1933; at Tallulah, La., it was higher than in any spring since 1932, and at College Station, Tex., the survival of weevils was highest of any year since the experiments were started 6 years ago. Although in most areas the weevil mortality was low during the winter of 1936–37, the number of weevils present in the cotton fields in the spring of 1937 depended chiefly upon their abundance during the fall of 1936. At Florence the weevils were more abundant early in 1937 than during any year since 1932. In Florida, southern Georgia, and Mississippi the weevil population was low. At Tallulah it was lower than during any recent year except 1936. Cage experiments and field observations indicated that many weevils emerged later from hibernation than usual. During the early season of 1937 conditions were not particularly favorable for the weevils, and at midsummer the prospects were that 1937 would be another light boll weevil year except in the South Atlantic and eastern Texas areas.

Mixtures of calcium arsenate and sulphur used for boll weevil control have in some experiments given greater gains in the yield of seed cotton per acre than undiluted calcium arsenate. These increased yields probably result from additional control of the cotton flea hopper and other hemipterous insects by the sulphur. These experiments indicate progress in developing an economical insecticide that will give practical control against the boll weevil, flea hopper, and other insects at the same time.

Mixtures of calcium arsenate and lime have in many instances given more profitable increases in yields than undiluted calcium arsenate. These mixtures have the advantage of reducing the dangers of soil injury and of heavy aphid infestation, and at the same time reducing the cost of weevil control. Although the tests in which the lime-calcium arsenate mixtures have given better results than undiluted calcium arsenate have been in the presence of comparatively light boll weevil infestations, this has been the normal condition in the boll weevil area during recent years.

In cage tests at Tallulah, La., with 20 different brands of calcium arsenate ranging from 11.2 to 0.2 percent in water-soluble arsenic pentoxide, as determined by the New York method, the boll weevil mortality ranged from 39 to

92 percent. There was apparently no correlation between boll weevil mortality and percentage of water-soluble arsenic pentoxide, or between the mortality and any of the chemical and physical characteristics of the calcium arsenates, such as free lime, molecular ratio, and particle size. Just what differences in method of manufacture or what physical or chemical qualities of the calcium arsenate cause this difference in toxicity has not been discovered.

SOIL INJURY FROM CALCIUM ARSENATE

The injurious effect to certain crops following the use of calcium arsenate in boll weevil control was first observed in eastern South Carolina more than 10 years ago. In general the soils where injury was noticeable were light, sandy soils of low fertility, and the most striking cases of injury were in fields where more than normal amounts of calcium arsenate had been used. The crops most seriously affected were the legumes, such as cowpeas and soybeans, oats, and to a less degree cotton. Although no cases of soil injury have ever been reported or observed in the Delta sections of Louisiana and Mississippi, where calcium arsenate dust has been used for boll weevil control more extensively and for a longer period than anywhere else, an experiment was started at Tallulah in 1931 by applying calcium arsenate to one plot of soil at the rate of 400 pounds per acre and comparing the crops planted on it with the crops on the adjacent plot that had not received any calcium arsenate. The applications of calcium arsenate were continued annually for 5 years or until a total of 2,000 pounds per acre had been applied, an amount in excess of what would be applied in 100 years for boll weevil control under ordinary farm practices. The average yield for the 6-year period since the experiment was started was 1,827 pounds of seed cotton per acre for the treated plot and 1,826 pounds for the untreated plot. So far as cotton production on this Delta soil is concerned there seems to be no danger from the continued use of calcium arsenate. However, soybeans and cowpeas are seriously affected by large quantities of calcium arsenate on this soil, as most of the plants soon died on the treated plot.

In Mississippi the study of the effect of calcium arsenate on seven major soil types and crops grown on them has been continued. Plots of each soil type received calcium arsenate at the rate of 50, 100, 200, 400, 800, and 1,600 pounds per acre in April 1935, and no arsenic has been added since that date. The germination and survival records for corn, cotton, and soybeans in the spring of 1937 show less injury than in the 2 preceding years. The same is true for the winter crops, Austrian Winter peas, hairy vetch, and oats. The yield of cotton and corn has not been materially reduced on any of the seven soils except where applications of 1,600 pounds of calcium arsenate per acre were made. The yields of Austrian Winter peas, oats, vetch, and soybeans have been reduced where 800 and 1,600 pounds of calcium arsenate per acre were applied. The effect of excessive quantities of calcium arsenate varied considerably with the different soil types. The Houston soil, black clay from the prairie section, is the most resistant to arsenical injury; and the Norfolk and Cahaba, light-colored, sandy soils are the least resistant. The yields and plant survival records indicate that the soils are recovering from the arsenical injury. Chemical analyses of the different soils treated with varying dosages of calcium arsenate showed that the range in decrease of water-soluble arsenic from 1935 to 1936 was from 23 percent to 80 percent. The maximum quantity of arsenic (As_2O_5) found in corn, cotton, and soybean plant grown in the arsenic-treated soils was 5.8, 10.0, and 8.0 parts per million, respectively.

COTTON FLEA HOPPER

Better control of the cotton flea hopper was again secured at Port Lavaca, Tex., by dusting with mixtures of arsenicals and sulphur than with sulphur alone. Mixtures of 10 percent of paris green and 90 percent of sulphur and of 20 percent of calcium arsenate and 80 percent of sulphur were about equally effective, and both mixtures gave much better control than sulphur alone. Excessive rains during the latter part of June and July in 1936 caused the cotton to shed the greater part of the bolls and considerably reduced the yield, but even with adverse conditions profitable gains were made by controlling the flea hopper. As the mixtures of arsenicals and sulphur are also of value against the boll weevil, leaf worm, and other cotton insects, it is expected that their use will reduce the cost of control where several insects occur together. Further experiments are needed to determine the best proportions of arsenic and sulphur to use under different conditions. Since the finding last year of the two cotton flea hopper egg parasites *Anaphes anomoccrus* Gir. and *Erythmelus*, n. sp., studies have been continued of their distribution, abundance, and life

history. The more abundant and important parasite, *Erythmelus* sp., has been found to occur in Arizona, Arkansas, Louisiana, Mississippi, and South Carolina, and in 36 counties in Texas. *A. anomocerus* has been bred from flea hopper eggs only from Arizona and Texas. An average of 25 percent of the 11,000 flea hopper eggs in the stems of croton plants collected in six States last year were parasitized. The information secured to date indicates that *Erythmelus* passes the winter within the overwintering eggs of the flea hopper and also parasitizes the eggs of other mirids.

PINK BOLLWORM

The introduced parasites *Microbracon brevicornis* Wesm. and *Exeristes roborator* F. apparently did not become established in Texas or Mexico after liberations over a 3-year period. The latter species, however, appears to be established in Puerto Rico, and further breeding and liberations of these species were discontinued. Recoveries of *M. kirkpatricki* Wilk. and *Chelonus blackburni* Cameron have been made near the points of liberation in Texas, Mexico, and Puerto Rico, and although establishment is not certain, the prospect is encouraging and farther liberations will be made. In the Presidio Valley, Tex., the Hawaiian strain of *M. mellitor* Say was recovered following initial releases last season, but its present status is undetermined.

Further studies of the native parasites occurring in Mexico have shown that one species of Diptera and at least four species of Hymenoptera, and possibly others, attack the pink bollworm. These native parasites are becoming of increasing importance, although they do not exercise sufficient control to prevent heavy annual infestations and damage. Technique for laboratory rearing of *Microbracon platynotae* Cush. and *Perisierola cellularis* var. *punctaticeps* Kieff. were developed, and small liberations were made to study the possibility of increasing their effectiveness. The former species was found to breed on an undescribed lepidopteron which occurs abundantly on blue weed (*Helianthus ciliaris*).

Three screened insect-proof field cages covering approximately 1 acre of land were completed and placed in use at Presidio, Tex., to prevent the movement of moths from surrounding fields from interfering with experiments to secure more definite information on the effect of cultural practices on the control of the pink bollworm. Additional tests with several quick-maturing eastern varieties of cotton again demonstrated that the damage from the pink bollworm in heavily infested areas can be considerably reduced by the selection of proper varieties, and by cultural practices such as close spacing and controlled irrigation, which hasten maturity and reduce the late seasonal damage and the build-up of the fall population which goes into hibernation. Although no resistance to the pink bollworm was evident in the varieties of cotton tested and all of them became 100 percent infested, there were indications that the grade of the lint was not lowered as much in the varieties with a high percentage of lint as in the varieties with a low percentage. In cage tests with cotton growing under controlled conditions, barium fluosilicate dust gave the greatest reduction in the number of worms per boll of any of the insecticides tested. Satisfactory control has not been secured with any of the materials tested, and further tests with this and other fluorine materials are in progress.

Several species of malvaceous plants were found to be hosts of the pink bollworm in Puerto Rico, but only the seed pods of the two trees *Montezuma speciosissima* and *Thespesia populnea* are considered important in providing a continuous supply of food for breeding during the closed season for cotton. It was definitely established that long-cycle larvae occur in Puerto Rico, the resting period of which may last for several months under dry conditions but is materially shortened under favorable moisture conditions. These studies are of practical importance in reducing the damage to cotton by proper adjustment of the planting dates to the rainfall distribution, and the local authorities have modified the regulations so as to prescribe uniform planting and closed seasons for the entire island instead of different seasons for the northern and southern parts of the island.

COTTON LEAF WORM

The cotton leaf worm made its appearance in southern Texas early in May 1936 and reached all cotton States except California before the end of the season. Although large quantities of arsenical poisons were used to control it, considerable damage was done in regions where it appeared early. Some regions were not reached until after the crop was mature, and the defoliation of the cotton plants greatly reduced boll weevil population to enter hibernation

in the fall of 1936, which partially accounts for the light boll weevil infestations in many areas at the beginning of the 1937 season.

In Oktibbeha County, Miss., the leaf worms appeared late in July; and about August 20, when the second generation of worms began to strip the plants, two tests were conducted to determine the amount of damage caused to the crop by the leaf worms. In these tests the average gain from dusting was 288 pounds of seed cotton per acre, the cost of treatment was $2.18, and the profit was $10.39 per acre. The increased production was due in part to the development of heavier bolls on the plants that had not been defoliated.

THRIPS

Thrips were reported from practically all cotton-growing States as especially injurious to seedling cotton during 1936. The extremely dry season was favorable for the increase of thrips. The most extensive damage to cotton occurred in the Southeastern States.

In Cullman County, Ala., during June a large proportion of the cotton plants on several thousand acres were defoliated by thrips. A series of tests with cube, nicotine, and pyrethrum as dusts and paris green and nicotine as sprays was conducted, but no noticeable control was obtained with any of them. With few boll weevils present and favorable seasonal conditions for cotton following the serious thrips outbreak in this region, a good yield of cotton was produced even though it was delayed 15 to 20 days by the heavy thrips infestation during June. In Washington County, Miss., a study of thrips injury to 40 commercial varieties of cotton revealed no difference in varietal infestation, but it was found that early chopping and allowing a greater number of stalks to remain in the hill decreased the percentage of terminal buds damaged. Destruction of the terminal buds caused a loss in seed-cotton production in 34 out of 40 varieties and a loss in staple length on damaged plants of 7 varieties. Several species of thrips were involved in injury to cotton.

HEMIPTEROUS INSECTS

Further studies on the complex problem of damage to cotton in Arizona by hemipterous insects confirmed previous results that the most injurious species are three stinkbugs of the family Pentatomidae, viz, *Euschistus impictiventris* Stål, *Chlorochroa sayi* Stål, and *Thyanta custator* F. All of these feed on the bolls and cause shedding, but the most noticeable injury is the lowering of grades caused by staining of the lint by pathogenic organisms which follow the puncturing of the bolls. The damage was greatest in Yuma County and lightest in Pima County, the average of bolls punctured in Arizona being 24 percent in 1936 as compared with 27 percent in 1935 and 23 percent in 1934.

Experiments in control with insecticides made on a field basis with power dusting machines gave promising results but were not conclusive as to the most effective insecticide combinations and methods of application. Population counts of hemipterous cotton insects were made throughout the season on crops and weeds to secure information concerning the host-plant relationships of the different insect species in connection with their migrations to the cotton fields.

THURBERIA WEEVIL

Studies over a 10-year period on the life history and habits of the Thurberia weevil when removed from its native host, *Thurberia*, and bred exclusively on cotton indicate that this weevil will not maintain itself on cultivated cotton under the usual cultural practices followed in southeastern Arizona. Experiments and observations show that where the stalks are destroyed in the fall and the usual irrigation practices applied it can be exterminated in 1 year where reinfestation from *Thurberia* plants does not occur. In the vicinity of natural infestation, where the weevil readily transfers from *Thurberia* to cotton, the infestation was greatly reduced by destruction of the *Thurberia* plants for a distance of 1 mile from the cultivated area. It appears that the greatest danger from the Thurberia weevil would be its introduction to sections with more favorable climatic conditions where the boll weevil occurs, as it interbreeds with the latter and might produce a biological race more resistant than the boll weevil to hot, dry weather and low temperatures.

BOLLWORM

In experiments for controlling the bollworm by insecticides, special attention was given to determining if the dusting schedule could be simplified by making a definite number of applications at fixed intervals. With the heavy bollworm infestations that prevailed in eastern Texas last season the best average in-

creases in yield were secured with four applications of calcium arsenate at 5-day intervals, beginning shortly after the first egg deposition on cotton. Calcium arsenate gave more effective control than a mixture of 90 percent of sulphur and 10 percent of pyrethrum, while the tests on increasing the arsenical content of calcium arsenate by adding 5 or 10 percent of paris green and on decreasing the arsenic by mixing with lime or sulphur were inconclusive.

In hibernation cages the number of moths emerging from overwintering pupae was greater in well-drained Lufkin fine sandy loam and Norfolk fine sand than in Blackland or Brazos River bottom soils; the differences in survival were not so great, however, where the soils were more moist.

PINK BOLLWORM CONTROL

The more important developments in the pink bollworm situation during the 1936 crop season were the finding of a new infestation in the lower Rio Grande Valley in both Texas and Mexico; the finding of reinfestation in several additional counties in the Texas Panhandle after a lapse of several years; and no recurrence of infestation in northern Florida for the second consecutive crop season.

The infestation in both of the above areas is very light. In the lower Rio Grande Valley of Texas four counties are involved, and they were placed under regulation on August 17, 1936. In the Texas Panhandle five counties are involved; a portion of two of the counties, however, was already in the regulated areas. This new territory was placed under regulation effective December 1, 1936. In both of the above instances it was necessary to include one or more counties in which no infestation was found. This was due to the fact that seed cotton is moved through such counties for ginning without regard to county lines. The Florida area was released from regulations effective October 14, 1936.

NEW INFESTATION IN LOWER RIO GRANDE VALLEY

The harvesting of the cotton crop in the lower Rio Grande Valley takes place much earlier than in any other section of the Cotton Belt. On August 6, 1936, gin-trash inspection was begun at Matamoros, Mexico, just opposite Brownsville, Tex. In the first sample of trash inspected specimens of the pink bollworm were found. Thereafter worms were found almost daily in trash from all gins in the Matamoros section until August 15, at which time inspections were discontinued. A total of 235 pink bollworms were submitted for identification, in addition to some 20 or 25 worms which were turned over to Mexican agricultural inspectors at their request. At Reynosa, Mexico, about 50 miles up the river from Matamoros, eight specimens of the pink bollworm were found, the first on August 12. These are the only two locations on the Mexican side of the river at which gins were operated. In the meantime, following the first finding at Matamoros, additional gin-trash machines had been sent to the valley to work on the Texas side. These machines began operating on August 10, 1936, and on the following day the first specimen of the pink bollworm was found at Brownsville. During the next few days three additional specimens were found at that place. On August 12 the first specimen was found at San Benito, and when inspections had been completed 19 specimens had been found at that location, but later in the season several additional specimens were found by regulatory inspectors. Both of the above places are in Cameron County. The only other finding in the valley was at Rio Grande City, Starr County, one pink bollworm being found on August 15.

On August 17, 1936, the pink bollworm quarantine was amended to add the counties of Cameron, Hidalgo, Starr, and Willacy to the lightly infested areas. While no specimens were found in Hidalgo and Willacy Counties, it was necessary to include them, as seed cotton is moved throughout the four counties for ginning without regard to county lines. Approximately 250,000 acres were planted to cotton in the four counties.

When the area was brought under regulation the bulk of the cotton crop had already been harvested. There was only one oil mill in the area, consequently a considerable volume of seed was moving to other mills in southern Texas. Immediately after the first specimen was found no seed was allowed to leave the valley until several mills which desired to continue receiving seed installed sterilizers, after which the seed was allowed to move to these mills, and immediately upon arrival was heated to 155° F. The lint was compressed at the two plants in the area or allowed to move to designated plants at Corpus Christi for treatment. It should be stated that all persons and firms involved cooperated wholeheartedly in carrying out the above treatment, even though no regulations were in effect when they were first begun.

Plans for enforcing the regulations during the coming season are somewhat different from those followed in the past. Instead of installing sterilizers at each gin, large central plants have been built at various points in the area. All seed for milling purposes will be treated at these plants, and after it has been heated to 155° F. it will be allowed to move to any point. Seed for planting will be stored in suitable places and, after the ginning season is completed, will be sterilized by the State. All seed, either for milling or planting, must be sterilized by October 1. A simple permit system is used whereby we have knowledge at all times of the amount of unsterilized seed remaining in the district and the person who has the seed. The harvesting of the 1937 crop got under way about the middle of June, and a number of the large central sterilization plants have been operating very satisfactorily.

The cotton crop is planted the latter part of January and in February. Picking and ginning begins the latter part of June and is largely completed by the end of August. Because of the mild climate cotton plants are seldom killed by frost, but remain alive throughout the fall and winter. Thus under usual conditions there would be plenty of fruit to maintain the pink bollworm throughout the year. The State has issued regulations that cotton stalks are to be destroyed after the harvesting season and not later than October 1. There will thus be no material on which the insect can propagate itself during a period of some 6 or 7 months. Another point in favor of this plan is that it will undoubtedly be of considerable advantage in reducing boll weevil carry-over. Farmers, ginners, and other influential citizens are greatly interested in the plan, and indications are that it will be carried out satisfactorily.

SITUATION IN OLDER REGULATED AREAS

The status of infestation is determined by laboratory inspection of green bolls if possible; otherwise by gin-trash inspection. If infestation can be established by laboratory inspection, gin-trash machines can thus be released for work in other areas. In some of the very lightly infested areas this cannot be done and it is necessary to do gin-trash inspection each season. In the regulated area of northern Florida intensive gin-trash inspections were carried on and practically all trash produced was inspected. By the middle of October ginning was largely completed: and in view of the thorough inspections carried on with negative results, and the negative results the previous season, the area was released from quarantine restrictions on October 14, 1936. In the Texas Panhandle results had been negative the previous season, and intensive gin-trash inspections were made this year. At three different points a total of nine pink bollworm specimens were found, indicating that an extremely light infestation still existed. In the remaining areas it was found that the status of the infestation was about the same as the previous year.

A summary of the amount and results of the various kinds of inspection is given in table 15.

TABLE 15.—*Summary of inspections for the pink bollworm in regulated areas, crop season of 1936*

District	Gin trash		Field		Laboratory	
	Bushels	Pink bollworms	Man-days	Pink bollworms	Samples	Pink bollworms
Northern Florida [1]	3,370	0	89	0	0	0
Lower Rio Grande Valley, Tex.[2]	3,922½	29	34	0	171	1
Texas Panhandle [3]	10,986½	9	4½	0	84½	0
Pecos Valley, N. Mex.	434	20	0	0	132	0
Pecos Valley, Tex.	10	22	0	0	62	0
Big Bend, Tex.	0	0	0	0	20	8,485
Hudspeth County, Tex. (southeastern part)	0	0	0	0	28	942
El Paso Valley, Tex.	5½	8	0	0	289	138
Mesilla Valley, N. Mex.	53	15	0	0	330	5
Tularosa, N. Mex.	0	0	0	0	0	0
Deming, N. Mex.	0	0	0	0	0	0
Duncan Valley, Ariz. and N. Mex.	28	0	0	0	38½	2
Safford Valley, Ariz.	394	37	0	0	51	0
Tucson, Ariz.	1,368	(4)	0	0	0	0
Total	20,571½	140	127½	0	1,206	9,573

[1] Released from regulations Oct. 14, 1936.
[2] Placed under regulation Aug. 17, 1936; part of gin-trash inspections made before that date.
[3] Previously listed as Western Extension.
[4] Results negative for pink bollworm, but 25 Thurberia weevils found.

INSPECTION OUTSIDE REGULATED AREAS

In planning the inspection program the most attention is, of course, given to areas most likely to become infested. Therefore intensive gin-trash inspections were carried on in southern Alabama and Georgia adjacent to the regulated area of Florida; also in the territory adjacent to the newly infested area in the lower Rio Grande Valley of Texas and in the territory adjacent to the Texas Panhandle regulated area. In the latter case three specimens of the pink bollworm were found, two in Howard County and one in Dawson County. This is the first finding in Howard County since the 1927 crop. These two counties, together with three adjoining ones, were added to the regulated area on December 1, 1936. A considerable amount of gin-trash inspection was also done in the Salt River Valley, Ariz., where an infestation was eradicated several years ago. Gin-trash or laboratory inspections are carried on as often as possible in all of the cotton States.

A summary of the various kinds of inspection and amount of material, together with the results, is shown in table 16.

TABLE 16.—*Summary of inspections for the pink bollworm outside regulated areas, crop season of 1936*

State	Gin trash		Field		Laboratory	
	Bushels	Pink bollworms	Man-days	Pink bollworms	Samples	Pink bollworms
Alabama	10,016	0	0	0	0	0
Arizona	4,937	0	0	0	0	0
Arkansas	304	0	0	0	0	0
California	1,879	0	0	0	0	0
Florida	795	0	0	0	0	0
Georgia	6,832	0	0	0	0	0
Louisiana	448	0	0	0	586	0
Mississippi	921	0	0	0	375	0
Missouri	4	0	0	0	0	0
New Mexico	0	0	0	0	9	0
Oklahoma	0	0	0	0	671	0
Tennessee	386	0	0	0	0	0
Texas	22,200	3	11½	0	1,007	0
Total	48,722	3	11½	0	2,648	0
Mexico:						
Baja California	1,024	0	0	0	0	0
Chihuahua	6¼	5	0	0	0	0
Nuevo Leon	1,460	0	3	0	0	0
Sinaloa	6¼	0	0	0	0	0
Sonora	156	0	0	0	0	0
Tamaulipas	393½	243	0	0	0	0
Total	3,046¼	248	3	0	0	0
Grand total	51,768¼	251	14½	0	2,648	0

CONTROL PROGRAM IN THE BIG BEND AREA OF TEXAS

By the 1932 crop season a very heavy pink bollworm infestation had developed in the Big Bend area of Texas. This constituted a very great danger, in that infestation might spread to the Cotton Belt. Therefore, in order to reduce the infestation and eliminate the danger of spread, a special control program was put into effect. This, briefly, consisted in thorough clean-up of cotton fields in the fall; the delayed planting of the cotton crop the following spring, so the peak of moth emergence would pass before cotton began fruiting; and the use of small plots of cotton to trap the later emerging moths. The program was carried on each year and very good results were being obtained. As the large worm population was reduced the farmers began making a better top crop. They naturally wanted to harvest this, and as a result fields were not ready for cleaning before worms began going into the ground in the fall to hibernate. There was some dissatisfaction over the delayed planting date of April 15. In the fall of 1936 farmers as a rule made

no effort to get their fields ready for cleaning, and indicated that they were going to plant cotton in the spring of 1937 before April 15. For this reason the control program has been abandoned, at least for the present.

The first cotton of the 1937 season was planted on March 17, and plantings were continued after that, with the last cotton being planted on May 26. Owing to the mild winter, considerable stub or volunteer cotton came up, and in one instance a 2-acre field of stub cotton is being cultivated. By the middle of May specimens of the pink bollworm could be found in small squares in this stub cotton. This is the situation in Presidio County. In Brewster County there is a very small cotton acreage and it is all controlled by one man, who is cooperating fully in continuing the program. A thorough field cleaning was made on this small acreage last fall, and no cotton was planted this spring until after April 15. The situation in the two counties should thus provide an excellent opportunity for a thorough test of the control program, and especially the value of early or late plantings.

WILD COTTON ERADICATION IN SOUTHERN FLORIDA

The eradication of wild cotton in southern Florida was begun in 1932 to eliminate a rather heavy pink bollworm infestation, and thereby remove this menace from the main Cotton Belt. The work has been continued each year since, but because of climatic conditions the most effective work can be done only during the fall, winter, and early spring. This season five small crews began work on the west coast in August 1936. The object was to remove seedling plants which would have fruited before regular eradication work got under way in the fall. Larger crews began work about the first of November, and as weather conditions were favorable excellent progress has been made. The work was carried on largely with W. P. A. funds; some Bureau funds, however, were used at the beginning of the season. A first clean-up was made on some 130 acres, on which 4,014 mature and 12,633 seedling plants were removed. During the recleanings 2,206 mature, 1,629,975 seedling, and 21,249 sprout plants were removed. At each recleaning there has been a notable decrease in the number of plants destroyed, indicating that progress is being made toward final eradication. For example, there was a decrease of 94 percent in the number of mature plants removed this season, 42 percent for seedlings, and 63 percent for sprout plants, as compared with last season. This is especially true along the west coast and is of most importance because this area is nearest to cultivated cotton. Since the work has been under way approximately 10¼ million wild cotton plants have been destroyed.

During previous seasons wild cotton bolls have been inspected as plants were destroyed, so as to obtain information regarding the status of infestation. As the work progresses fewer bolls are encountered, and this season, instead of inspecting the bolls in the field, they were preserved and sent to Miami to be inspected after eradication work was discontinued. Inspection of this material had just gotten under way at the end of June and a few specimens of the pink bollworm had been found. These were from bolls collected on keys off the coast of Monroe County, and are farthest removed from domestic cotton.

An important phase of wild cotton work was a survey made with an autogiro during March and April 1937. The autogiro was loaned to this project by the Dutch elm disease project. An area of some 1,900 square miles was covered during the survey, and as a result 24 new locations capable of sustaining wild cotton were located. These locations were charted on a map, and it will be a fairly simple matter for clean-up crews to reach them and destroy any cotton that might be present. Of equal importance is the fact that many hundred square miles of swamp and everglades have been found to be unsuitable for wild cotton growth, and can now be eliminated from further consideration in the eradication program.

THURBERIA WEEVIL CONTROL

In the area regulated because of the Thurberia weevil in southern Arizona approximately 6,000 acres were planted to cotton this season. Of this amount some 5,000 acres are of the short-staple variety and 1,000 acres of the Pima or long-staple variety. The inspection of gin trash indicated a light infestation of the Thurberia weevil in the cultivated cotton, 25 specimens being found.

The majority of the cotton acreage is in the Marana section, about 18 miles northwest of Tucson. Most of the specimens came from the small acreage south of Tucson.

The native host of the Thurberia weevil is *Thurberia thespesioides* Gray, a malvaceous plant closely related to cotton. This plant occurs in a number of mountain ranges in southern Arizona, particularly the Tortollita and Santa Catalina Ranges, which are nearest to the cultivated cotton, and the infested plants furnish a continuous source of reinfestation to the cultivated cotton. In 1935 emergency relief funds were provided by the W. P. A. to attempt eradication of the plants and thus remove the menace from cultivated cotton. Active work was begun in August 1935 and has been continued throughout the present fiscal year. Work in the Tortollita Range was completed early in 1936, and since that time work has been carried on in the Santa Catalina Range. In the beginning the laborers were transported in trucks to and from Tucson each day. As soon as all of the area readily accessible from Tucson had been worked it was necessary to establish a camp in the mountains. The camp had to be moved several times as various sections were completed. During the fiscal year 65,245 acres were worked in the Santa Catalina Range and 562,488 *Thurberia* plants destroyed. Many of these plants were heavily infested with the Thurberia weevil. Since the work has been under way over 1,000,000 *Thurberia* plants have been destroyed.

BEE CULTURE

This season 400 packages of bees have been under observation in the apiaries of cooperators in a continuation of the supersedure study. In last season's work, of 606 queens for which complete records have been compiled, 8.26 percent were lost in shipment or by other manipulations, 8.99 by supersedure, and 3.3 percent were replaced by the beekeeper within 2 months after receipt. This indicates that the country's annual loss of queens may be as high as 20 percent from the foregoing causes alone. During the preceding season it was found that supersedure is little influenced by a variation in population of a colony such as that occasioned by adding brood or bees. During the current season the effect of the availability of pollen is being observed. So far the shipping of queens, either in mailing cages or in packages of bees, appears to have no effect on the amount of supersedure.

Preliminary work indicates that with proper equipment, good management, stimulative feeding, and an early pollen supply, good colonies in the South can produce at least 20 pounds of package bees in one season.

With the cooperation of the Vanderbilt Medical School it was found that vitamin E is not present in royal jelly. The vitamin A and B content is now being studied in a continuation of the endeavor to find why queen and worker become differentiated from each other.

Beekeeping in the Sierra Nevada and Cascade Mountains has been subjected to serious losses by bears. With the cooperation of the Zoology and Agricultural Engineering Departments of the University of California, an electric fence charged from a battery has been devised that has worked successfully in keeping bears out of apiaries when a good ground was provided for the electric current.

Cooperative work with the Oregon Agricultural Experiment Station showed that nectar from floral nectaries of various vetches under observation contained a lower sugar concentration than did nectar from the extrafloral nectaries of the same plants. For this reason bees ignored the blossoms in favor of the extrafloral nectaries. Hairy vetch proved an exception, since the sugar concentration of nectar from the blossoms was higher than that from the extrafloral nectaries. Consequently bees worked the flowers of this plant. The sugar content of nectar from alsike and crimson clovers compared favorably with that of vetches in blossom at the same time. Nectar from red clover was scarce and of a low sugar concentration not attractive to bees.

Work was begun on testing various races and strains of bees for resistance to American foulbrood by the inoculation of colonies with definite dosages of the causative organism. Thirty-nine queen bees from stock held to have shown some degree of resistance were accumulated in 1936 and 12 of them were tested in colonies. Four showed more or less indication of resistance since they cleaned up the slight amount of disease developing as a result of inoculations.

The standard dose being used for the inoculation tests consists of 10 times the minimum infections dose or 500,000 spores per cubic centimeter in 1 liter

of sugar sirup. To facilitate the preparation of this solution, a method has been devised for preparing in powdered form measurable quantities of approximately known numbers of spores of *Bacillus larvae*. Cultural studies of various strains of the organism have shown wide variation in length of the incubation period and in the greatest dilution that will give growth in culture.

Losses of queens shipped under present standards are too high, particularly during hot weather. Provision for a continuous water supply has given promise of reducing such losses, while for queens caged for long periods, pollen added to the queen-cage candy in addition to a water supply has been shown to be beneficial in preliminary tests.

It has been found that relative humidity has a more marked effect on the longevity of caged bees than any other environmental factor. Relative humidities of about 20 to 25 percent, together with 50-percent sucrose solutions in water and with additional water available, provide satisfactory conditions for caged bee studies. The most suitable temperature conditions have not been determined, but the length of life at temperatures of 84° to 93° F. is sufficiently long for most comparative testing.

Studies on the lethal effect on bees of arsenicals used as insecticides show that a dose containing only 0.05 to 0.10 microgram of elemental pentavalent arsenic is sufficient to cause a significant shortening of life. The work also indicates that calcium arsenate ($Ca_3(AsO_4)_2$) is somewhat more toxic to bees than acid lead arsenate ($PbHAsO_4$).

Preliminary crosses and backcrosses of the Italian and Carniolan races by the Watson method of artificial insemination gave no indication of the complete dominance of either yellow or black as far as coloration of abdomens and scutella of the worker progeny is concerned.

What has been tentatively designated as a haplo-diploid mosaic drone was discovered in the experimental apiary at Beltsville, Md. It bears dark hairs on one side of its thorax and yellow hairs on the other, and shows some difference of coloration in the two sides of the anterior abdominal tergites.

Studies on two different commercial strains of the Italian bee reared in this country showed one to be approximately twice as good as the other in honey-storing ability, and also to be definitely superior in amount of brood reared and in drawing out foundation.

Spores of *Bacillus larvae* failed to grow in culture after they were boiled in water for 6 hours and also after they were autoclaved at 15 pounds' pressure for 30 minutes. With all shorter periods of heating, growth was obtained in some of the cultures. Three hours of exposure to flowing steam failed to destroy all the spores. In concentrations ranging from 1 pound in 5 gallons to 1 pound in 30 gallons of water, both potassium hydroxide and sodium hydroxide failed to destroy spores of *B. larvae* within 3 days.

European foulbrood did not recur in colonies of Caucasian or Carniolan bees but did recur in all experimental colonies of common black bees.

INVESTIGATIONS OF INSECTS AFFECTING MAN AND ANIMALS

SCREWWORMS AND OTHER BLOWFLIES

Further research on the biology and habits of screwworms and other blowflies has developed promising methods of determining the influence of climatological and other ecological factors which favor the development of, and are responsible for, local outbreaks and the natural dissemination of these pests.

In the overwintering area in Texas, during 1937, foci in which factors appeared favorable for the rapid building up of screwworm fly abundance were located at certain points along the Rio Grande and in the lower Rio Grande Valley. By following the natural migration of the fly from the overwintering area and studying the rate at which the flies increased after reaching given localities, it was determined that all of Texas, parts of western Louisiana, and the lower desert section of Arizona were reinfested early in July. In 1937 the rate of migration was about the same northward as in 1936 but was more rapid toward the east. After spreading over the Gulf Coastal Plain in Texas the screwworm population reached its peak early in May. Along the escarpment of the Edwards Plateau the build-up of the fly population was at a more rapid rate and did not reach its peak until early in June. On the Edwards Plateau the flies were continuing to increase at the end of July. With the

exception of a narrow strip along the lower Gulf coast, the maximum fly abundance on the Gulf Coastal Plain was never more than 50 percent of that in the area along the escarpment.

Cochliomyia americana C. and P., the primary screwworm fly, overwintered in Texas south of the Edwards Plateau escarpment and as far eastward as San Antonio. Overwintering also occurred under experimental conditions at Valdosta, Ga., and Gainesville, Fla. Results of hibernation studies indicate that the fly is unable to survive the winter in Arizona or at Menard or Dallas, Tex. These studies also showed during the winter of 1936–37 a possible maximum "carry-over" period, that is, from the egg to the death of the last fly in the same generation, of approximately 3 months at Uvalde, Tex., and somewhat longer at Gainesville, Fla., and Valdosta, Ga.

Other investigations on the biology and habits of the screwworm indicate that in certain areas the percentage of infestation in wild animals is as high as or higher than in livestock; that the greatest increase in numbers of this species of fly is in areas having a high wild-fauna population; and that in areas where control measures are efficiently carried out for livestock the fly population is maintained by the breeding of the parasites in wild animals.

Studies on the effect of acidity and moisture content of the soil on the emergence of *Cochliomyia americana* have shown that grown larvae are able to withstand greater extremes of acidity and alkalinity than exist naturally in the soil. Nearly 50-percent emergence was obtained in sand one-fourth saturated with 0.2N sulphuric acid, and also in sand one-fourth saturated with 1.0N potassium hydroxide. Decreasing tolerance for acid or alkali media occurred with increasing saturation.

A distinct forward step in the control of screwworm flies has been indicated by the results obtained in experiments with phenothiazine as a larvicide. This material when applied to a wound prevents the establishment of newly hatched larvae in the tissues of the host but does not repel flies from the wound or prevent oviposition. Thus injury to the animal by the parasite is prevented and at the same time the breeding of the flies is greatly reduced. Considerable attention has been given to the testing of numerous other organic and inorganic substances producing the same effect as phenothiazine, and some of these are distinctly promising and warrant further investigation.

Other experiments for the development of larvicides and repellents for blowflies have shown that a mixture of 73.5 percent of a pine oil, 1.5 percent of 95-percent nicotine, and 25 percent of a wetting agent gave satisfactory control of all stages of the larvae of *Cochliomyia americana* in wounds. Benzol made miscible with water by the addition of 10 to 25 percent of a wetting agent was much more effective in killing screwworm larvae in wounds than was benzol alone, when no cotton packing was used in the wound.

Preliminary tests were made of the following larvicide-repellent combinations: (1) A pine oil 73.5 percent, nicotine (95 percent) 1.5 percent, and a wetting agent 25 percent; and (2) benzol 55 percent, diphenylene oxide 20 percent, and a wetting agent 25 percent. The tests indicated that as compared with benzol, when the latter is used with cotton packing and followed by applications of pine-tar oil, they are superior in killing the larvae, reducing the number and severity of infestations, and reducing the healing period of wounds.

Experiments to determine the fraction or fractions of pine-tar oil responsible for its fly-repellent property and its injurious effect on the skin of animals have shown that a certain fraction of pine-tar oil appears to be more repellent to blowflies than pine-tar oil. This material, however, causes more severe injury to the tissues of animals. Other fractions of pine-tar oil tested showed no value as fly repellents. Fraction 1 of retene oil was about as repellent as pine-tar oil but was more injurious than the latter when applied to the normal skin of animals.

Attempts to infect *Cochliomyia americana* experimentally with a species of *Empusa*, a parasitic fungus fatal to *C. macellaria* and *Phormia* spp., were unsuccessful.

Sodium cyanide (one-fourth ounce per gallon of water) and carbon disulphide (one-eighth pint of a 1:1 emulsion with neutral Turkey Red oil to 1 gallon of water) were both 100 percent effective in destroying the larvae of *Cochliomyia americana* and other blowflies in the soil when applied at the rate of 2 gallons per square yard of soil surface. The former solution was also effective in killing pupae of *C. americana* in the soil.

Studies on the life history and habits of the Gulf coast tick, one of the most serious predisposing causes of screwworm attack in the Southeast, have indicated practical methods of controlling this species of tick.

To study the screwworm problem and develop practical control measures under range conditions the Bureau has established a ranch experiment station at Menard, Tex., comprising some 1,200 acres and using approximately 900 sheep, goats, and cattle as experimental animals.

CATTLE GRUBS

Experiments with solutions of rotenone have yielded a simple and efficient method for reducing the abundance of cattle grubs. A solution composed of 50 cc of benzol, 5 cc of cresol, 45 cc of liquid petrolatum, and 1 g of rotenone was found to be as efficient when applied to the surface of the skin and rubbed with the fingers as when the solution was injected into the opening of the lesions individually. The survival of grubs from such general applications ranged from 1.25 to 7.69 percent. When this method is used, from three to five times as many cattle can be treated by one operator as when the solution is injected into the lesions individually. The method is particularly suited to the treatment of dairy cattle and provides a cheap, quick remedy against the losses to the dairy industry occasioned by these pests.

A histological study of the migrations of the larvae in the host have corroborated earlier findings resulting from gross examination. The investigations also showed that the esophagi invaded by the cattle grub exhibited an extensive inflammatory edema, which was confined mainly to the outer layers and was composed principally of a hematogenous exudate, with eosinophils, plasmocytes, and lymphocytes predominating. Infiltrating fluids caused distortion and injury resulting in an apparent weakening of the walls of the esophagus.

CATTLE AND HORSE LICE

In experiments on the control of lice on cattle and horses where the use of a dipping vat is not feasible, as is often the case during the winter months, the powdered roots of derris and devil's shoestring have been found efficient and economical because of their effectiveness even when greatly diluted. Derris root containing 3 percent of rotenone was effective for both biting and sucking lice when diluted to 0.125 percent rotenone by mixture with diatomaceous earth in the ratio of 1 part to 23 parts of the diluent by weight. Powdered devil's shoestring diluted to the same concentration of rotenone was equally effective.

It was found also that a solution of 0.5 g of rotenone in 100 cc of carbon tetrachloride, when sprayed lightly into the coat of an animal with an ordinary hand sprayer, is a very prompt and effective treatment. The carbon tetrachloride evaporates almost instantly, leaving the fine particles of rotenone in the hair. While this preparation is more easily and more rapidly applied than the powders, the materials are more costly, since about 4 fluid ounces of the solution was required to treat a full-grown animal.

GOAT LICE

Following the experimental work of the Bureau which demonstrated the effectiveness of 325-mesh wettable sulphur for the control of lice of sheep and goats, many ranchmen in certain parts of the Southwest are enthusiastically employing this material for ridding their flocks of these parasites. The treatment is reported to increase the mohair production approximately one-fourth pound per animal. In order to make the sulphur usable as a dip with all kinds of water, over 400 tests have been made to determine the best wetting agent to be used in connection with the sulphur in alkaline waters. These tests have determined that at least six combinations of neutral sodium oleate with sulphonated-alkylated diphenyl, a sulphonic acid of an aromatic hydrocarbon, and a sodium salt of alkyl ester of sulphosuccinic acid are suitable as wetting agents in water rendered alkaline by the presence of sodium or magnesium salts.

FLY SPRAYS AND REPELLENTS

In investigations in the development of more efficient fly sprays and repellents, especially for use on livestock and in barns, a biological method of assaying the insecticidal value of fly sprays has been perfected in which use is made of an accurately regulated mechanism governing the air stream, dosage,

etc. The insects are sprayed in a regulated air stream and allowed to recover in a ventilated cabinet. Initial effect and rate of recovery from median lethal doses are used as criteria of toxicity.

An insect olfactometer has been designed and built that will aid in determining the relative attraction or repellence of chemicals, and various odoriferous substances can be rather accurately measured.

In these studies a moderately satisfactory method of producing large numbers of stableflies was developed. Adults are fed acidulated beef blood, and the larvae are reared on a medium of a moist mixture of crimped oats and rotten straw.

SHEEP TICK

Studies on the biology and habits of *Melophagus ovinus L.*, an important northern parasite of sheep, indicate that during the last 15 to 20 years a strain of the insects has developed which will withstand the hot, dry weather of the Southwest and that it is rapidly becoming a serious problem upon the ranges of that section of the country. Preliminary tests on the control of this pest have shown that 325-mesh wettable sulphur used as a dip is effective in destroying all the adults infesting an animal, but that it is not effective in killing pupae.

TICKS AFFECTING MAN AND ANIMALS

Tests to determine the efficacy of methods usually employed in killing the American dog tick and the winter tick show that the fully engorged females of these two species are very resistant to the chemicals usually employed to kill ticks. It was found, however, that derris powder containing from 1 to 3 percent of rotenone was effective in killing all but the engorged females of the American dog tick and that derris powder and devil's shoestring containing approximately the same amount of rotenone was satisfactory in ridding horses and cattle of the winter tick. From 4 to 9 ounces of derris powder or devil's shoestring was required to treat an adult horse or cow.

Because of the increasing importance of Rocky Mountain spotted fever in the East, investigations are under way to determine methods of destroying the tick vector (*Dermacentor variabilis*) over relatively large areas. These studies are concerned principally with the destruction of the ticks on wild and domestic animal hosts and the use of insects parasitic on the ticks.

In order to place work on the eradication of the southern cattle tick (*Boöphilus annulatus australis* Fuller) in Puerto Rico on a sound basis a study of the host relations, habits, and life history of this tick was begun in cooperation with the Puerto Rico Reconstruction Administration and the Bureau of Animal Industry of the United States Department of Agriculture.

HOUSEHOLD AND STORED-PRODUCT INSECTS

Considerable work was done in assembling and publishing information on the control of cockroaches, bedbugs, ants, clothes moths, carpet beetles, fleas, and other household insects to meet the needs of the Bureau in answering thousands of requests from individuals, exterminating companies, and commercial concerns for methods of combating these pests.

Cooperation has been extended the custodians of the various Federal buildings and to quartermasters charged with protecting furnishings, fabrics, and foodstuffs subject to insect attack.

Inspections were made of certain brush-manufacturing plants and wholesale houses in Maryland, Virginia, North Carolina, South Carolina, Georgia, and Alabama for infestations of the furniture carpet beetle (*Anthrenus vorax* Csy.) to determine the extent of spread of this recently introduced and serious pest. Advice on methods of control was given to the companies concerned. The brush factory of the Federal Bureau of Prisons at Fort Leavenworth, Kans., which was heavily infested with this beetle, was fumigated under the technical direction of a representative of the Bureau.

A large number of tests, chiefly in cooperation with the Army and Navy quartermasters and the Federal Trade Commission, have been made to determine the effectiveness of various moth-proofing solutions for protecting fabrics against damage by moth and carpet beetle larvae. The results reveal a distinct improvement in the solutions now employed by commercial concerns over those

formerly used, but there is no indication that a moth-proofing agent has yet been developed which imparts a permanent insect-resistant quality to the fabrics.

Observations on the larder beetle indicate that the insect has only one generation a year in northern Vermont, whereas at Washington, D. C., several generations may be produced. The effectiveness of hydrocyanic acid gas in destroying this pest in large warehouses and in carload shipments of liver meal and other animal products to be used as fertilizers was demonstrated.

MOSQUITOES

Recent experiments have shown that paris green, when mixed with water and applied as a spray, is very effective for destroying the subsurface-feeding larvae of culicine mosquitoes. In a number of field tests with this arsenical, carried out under various conditions, high percentages of larval control have been obtained with several important economic species, including the salt-marsh mosquito *Aedes taeniorhynchus* Wied., the fresh-water species *Psorophora columbiae* D. and K., and the southern house mosquito. Treatments were effective when the arsenical was applied with a sprinkling can or knapsack sprayer at rates as low as 1 pound per acre. Two preliminary tests were made with an autogiro as a means of applying the spray, and the results indicated that this type of airplane, with its comparatively low speed, could probably be adapted for treating large breeding areas that are not otherwise accessible.

Samples of calcium arsenite having a comparatively high percentage of water-soluble arsenic were found to be nearly as toxic for mosquito larvae as paris green. This product may therefore prove to be a satisfactory substitute for use in both anopheline and culicine mosquito control. While this form of arsenical is apparently not yet available commercially, it seems probable that such a product can be produced at a cost appreciably lower than that of paris green.

An acetone solution of phenothiazine was known to be much more toxic for mosquito larvae than the undissolved material. Recently it has been found that the addition of a sulphonated petroleum oil reduces greatly the amount of acetone solvent required, while providing a combination that is readily miscible with water. In preliminary laboratory experiments this solution gave 100-percent mortality in tests with larvae of *Culex quinquefasciatus* at a phenothiazine dilution as high as 1 to 2,000,000.

A study was made of the distribution of the important tropical malaria mosquito *Anopheles albimanus* Wied., with special reference to the possibility of its introduction into the Southeastern States. At present this species occurs in the United States only in the lower Rio Grande Valley of Texas, and, judging by the apparent temperature limitations there, it seems unlikely that it could survive in other portions of the Gulf Coast States except in southern Florida, where climatic conditions would appear to be favorable for its propagation if once introduced and allowed to become established.

Studies on the biology and habits of the two floodwater mosquitoes *Aedes aldrichi* D. and K. and *A. vexans* Meig. in the Pacific Northwest, particularly along the lower Columbia River, have shown that both species and both sexes were dispersed in all directions, both with and against general wind currents, for a distance of from 2 to 5 miles from the breeding ground, and that there was a gradual dispersal up the tributaries of the Columbia River for distances of 8 and 10 miles. The extreme longevity of these species was 112 days for females and 94 days for males. In years of low floods of the Columbia River—that is, about 10.5 feet—73.4 percent of the mosquito population is *Aedes vexans* and 26.6 percent *A. aldrichi*. In years of average high floods—about 19.7 feet—only 13.8 percent of the population is *A. vexans* and 86.2 percent *A. aldrichi*. Studies of the factors influencing the hatching of eggs of these two species show that in the dormant stage they quickly lose their viability upon exposure to relatively long periods of inundation; that under normal conditions they may remain viable for at least 3 years in nature; and that overwintering eggs will not hatch when moistened with river or tap water but will respond quickly when treated with various infusions, phosphates, asparagine, and a number of other amino acids. These data have an important bearing on the type of mosquito-control methods to be used and should be taken into consideration in connection with any control work in areas where *Aedes vexans* and *A. aldrichi* are serious pests.

In cooperation with the Bureau of Biological Survey, the Civilian Conservation Corps, and the State agencies concerned in mosquito control in Maryland, New Jersey, and Delaware, work was begun to assist the C. C. C. camps to carry out more effectively the mosquito-control projects to which they were assigned in these States.

Surveys were made to determine the more important mosquito-breeding areas. Advice was also given as to the most practical procedure to be followed in abating the mosquito plague in different areas. Intensive surveys of the fauna and flora of the marshes are being made to determine the relationship between mosquito-control operations and the disturbance of wildlife on tidal marshes, and to weigh the probable influence of different types of control on these forms of life. These surveys are not yet complete but present data indicate that with a knowledge of the soil types, water levels, and other factors, the time and expense of ditching marshland may be kept at a minimum, the mosquito control made more effective, and wildlife disturbed but little. If there is no great change in the salinity of the water passing into them, marshes which have a compact soil, are flooded by lunar tides, and have a fairly good tide range in the ditches will maintain their original vegetation in good condition. On the other hand, marshes which have a porous soil on which water has been practically impounded over long periods will show marked changes if the surface water is removed and the water table permanently lowered.

SAND FLIES

For relief from the annoyance of sand flies in houses it has been found that a mixture of 1 part of commercial pyrethrum extract and 20 parts of very light lubricating oil applied to the window and door screens gives good protection for a considerable length of time to persons inside the houses.

SURGICAL MAGGOTS

Following the discovery of the value of urea as a healing agent, considerable work of a service nature has been performed by the Bureau in supplying information to both doctors and laity as to where urea could be purchased and the methods of its application. Much work of the same nature is still required on the subject of allantoin, another compound found in maggot secretions.

The search for healing agents present in maggot excretions was continued during the year. Two substances, ammonium carbonate and ammonium bicarbonate, which occur in the excretions were given preliminary tests, but in general the results obtained with them did not appear to be distinctly beneficial, and the experiments were discontinued.

In studies of the anatomy and physiology of blowfly maggots to determine how these organisms produce their healing or beneficial effects, considerable improvement has been made in research technique. A vital dye, alizarin, has been used with much success in determining the hydrogen-ion concentration of various parts of the alimentary canal. It is given with the food of the larvae, and when eaten it stains various parts of the digestive tract a characteristic red or yellow. This same dye is being used to determine calcium metabolism of the fly maggots.

FIRE ANTS

Numerous tests of methods to control fire ants (*Solenopsis* spp.), which are so destructive to young quail and otherwise injurious in the Southeastern States, have shown that approximately 50 percent of the fire ant colonies can be destroyed by applying a solution of sodium cyanide containing 1 ounce of the chemical to a gallon of water. Applications of more than 1 ounce of sodium cyanide per gallon of water increase the efficiency of the method in sandy soils, but 1 ounce of the dry cyanide placed 3 to 6 inches deep appears to be more efficient than the liquid material on clay soils, although less efficient on sandy soils. Better kills are obtained if the liquid cyanide solution is poured down the galleries rather than into holes punched into the ground around the colony. Greater kills may be expected if the colonies are treated as early as March and April rather than in May, June, or July, and a greater percentage of the colonies were destroyed when the materials were applied in wet weather than under dry conditions.

Tests with carbon disulphide, both as a liquid and as an emulsion, and chloropicrin indicated that they were satisfactory materials for destroying the colonies.

SCREWWORM CONTROL

The cooperative campaign for control of screwworms was similar to that of last year, except that some of the educational phases were of a more advanced nature, demonstrations on fundamental livestock practices for prevention of screwworm attacks were carried on by cooperating stockmen, and most of the supervisors were assigned to larger territories. By employing 155 field men for varying periods the program was effectively extended to practically all infested areas of the Southern States.

The work for the year again made use of the State and Federal agencies interested in livestock. The State screwworm control committee in each State cooperated and assisted in effective work with county agricultural agents, veterinarians, teachers of vocational agriculture, and individual stockmen and farmers. The procedures were directed from field headquarters at San Antonio, Tex., and supervisors were supplied with posters, circulars, handbills, timely articles for the press, radio talks, exhibits, and supplies. In each State the supervisors received special instructions on the life cycle, methods of detecting and preventing cases, proper methods of treating cases with benzol and pine-tar oil, and the principal variations in the causes of screwworm abundance in different areas. At these conferences the good preventive measures endorsed by State agencies usually included (1) controlled breeding to reduce cases in navels and in mothers of young; (2) dehorning of young animals during cool weather and horn tipping of older animals to reduce infestations caused by horn hooks; (3) use of bloodless emasculators on cattle, sheep, and goats in order to avoid cases which usually follow the use of the knife; (4) control of the Gulf coast and spinose ear ticks; (5) elimination of the use of catch dogs; (6) avoiding rough handling of livestock so as to reduce snags and scratches; and (7) the use of dehydrated pine-tar oil on all open wounds to aid healing and to prevent flies from laying eggs on wounds.

During the year 7,608 demonstrations of recommended practices of handling and managing livestock for prevention or treatment of injuries of animals were made by good stockmen. These demonstrations were conducted by owners of farms and ranches as examples for different communities, and limited quantities of treating materials were furnished them. Small quantities of materials for treating carry-over infestations of the winter were also furnished to stock owners who cooperated in combating screwworms when the incidence of cases was at a low point. Altogether, 5,398 gallons of benzol and 7,262 gallons of pine-tar oil were used for such purposes.

CONTROL WORK IN THE SOUTHEASTERN STATES

Activity of screwworms during the winter is restricted to areas in which the mean winter temperature is above 55° F. This natural control does not become effective early enough in the fall to aid in preventing destructive outbreaks when animals are marked, castrated, and fattened in the fields of the Southeastern States. The high control of the pest obtained during the fall of 1936 was due to good cooperation by stock owners throughout the year. Such continuous work resulted in confining the pest principally to the southern counties of Georgia and to the peninsular portion of Florida, where there was some activity during the winter months. The additional work carried on in these areas during the winter (1) reduced the stock of parent flies in the spring; (2) served in keeping screwworms in check so that a big population did not breed up in navels of young animals; (3) greatly reduced the infestations from surgical operations; and (4) retarded spread of the pest.

The following are the average rates of infestation among 100,000 animals in Florida: In 1935, July 3,447, August 3,613, September 2,802, October 2,049, November 2,148, December 1,105; in 1936, January 374, February 257, March 236, April 687, May 863, June 797, July 581, August 489, September 653, October 853, November 454, December 93; and in 1937, January 240, February 284, March 214, April 345, May 694, June 940, and July 867.

The retardation of spread by control work was strikingly illustrated by the first occurrence of cases of screwworms at Hinesville, Ga., during the last 2 years. In 1936 the first cases occurred on May 1, and in 1937 the first case did not occur until May 25. This difference in the early occurrence of cases is attributed only to control work which delayed spread of the pest and enabled southern Georgia to escape a generation of screwworms. The delay of spread

was accomplished in spite of the fact that high temperatures, beginning in Florida as early as the last week of December, greatly favored an early build-up of screwworms for the year.

In South Carolina reports were received of 73 cases, and in 6 instances, representing 5 counties, primary screwworms were definitely identified. In each instance the pest was promptly stamped out by the efforts of local stockmen. In Georgia the pest was prevented from spreading from the open-range area to farming sections, and was not permitted to invade animals that were fattened in bean and peanut fields in the fall. In Alabama screwworms were identified from two widely separated counties, Barbour and Sumter, but both infestations were promptly stamped out by diligent efforts of stock owners. In Louisiana cases occurred at stockyards and horse-trading centers late in the fall or early in the winter. Prompt treatment of such cases by employees of the yards apparently stamped out these imported infestations.

The cumulative results of screwworm control work in the Southeast are reflected in the reported or estimated cases and in the death rates during the last few years. In 1933 there were approximately 75,000 cases of screwworms in Georgia, and animals in about 20 counties in northern Florida became infested. By the end of 1934 it was estimated that 1,300,000 cases had occurred in the Southeastern States, and an educational and demonstrational program was considered a necessity. In 1935, when control work was carried on, only 228,660 cases were reported by local supervisors, and in 1936 there was a further reduction to 48,737 reported cases. A summary of the educational campaign of the year 1937 is given in table 17. During 1934 it was estimated that approximately 12 percent of the infested animals in the Southeast died of screwworm infestation. In 1935 there were 2,520 deaths among 100,000 infested animals. In 1936 only 322 deaths were reported among 45,829 infestations in Florida, or at the rate of 702 deaths among 100,000 infested animals. The reported cases in the Southern States are summarized by weeks for the year 1937 in table 18.

TABLE 17.—*Summary of educational work on screwworm control, fiscal year 1937*

State	Meetings and demonstrations held	Attendance at meetings and demonstrations	Stockmen visited on farms and ranches	Exhibits	Attendance at exhibits	Circulars and bulletins distributed	Posters and handbills distributed	Newspaper articles published	Radio talks given	Practices demonstrated by stock owners
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Alabama	114	4,266	5,498	9	12,482	4,316	171	36	0	1
Arizona	149	1,465	4,676	19	32,275	1,494	81	19	0	159
California	288	7,891	5,678	33	110,516	9,938	169	52	0	73
Florida	2,685	24,437	81,326	38	295,391	27,813	51,536	622	5	4,383
Georgia	1,741	28,531	43,395	19	65,470	37,810	1,332	404	6	2
Louisiana	7	96	1,831	4	536	1,254	2,330	22	0	23
Mississippi	33	1,355	2,585	7	28,500	5,921	651	20	0	36
New Mexico	239	7,841	7,504	28	162,785	8,137	388	39	3	943
Oklahoma	238	12,251	4,003	153	67,904	7,404	350	25	8	68
South Carolina	94	2,681	2,381	8	33,010	2,937	797	34	0	12
Texas	1,984	39,380	59,439	845	499,625	66,028	3,318	912	5	1,908
Total	7,572	130,194	218,316	1,163	1,308,494	173,052	61,123	2,185	27	7,608

TABLE 18.—*Reported cases of screwworms and maggots in the Southern States, fiscal year 1937, by weeks*

Week ended—	Alabama	Arizona	California	Florida	Georgia	Louisiana	Mississippi	New Mexico	Oklahoma	Texas	South Carolina	Total
1936	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
July 3	33	------	10	1,107	13	3	2	------	0	4,656	1	5,825
July 10	24	------	0	828	21	1	3	1	9	4,490	5	5,382
July 17	9	8	0	839	15	16	4	1	17	7,105	7	8,021
July 24	29	9	0	834	18	6	4	396	23	14,650	3	15,972
July 31	20	49	0	772	4	9	0	469	71	7,647	15	9,056
Aug. 7	18	34	2	725	21	12	2	5,367	21	6,740	9	12,951
Aug. 14	6	44	1	834	24	3	3	894	15	8,443	1	10,268
Aug. 21	8	71	21	916	22	8	2	1,279	134	6,273	5	8,739
Aug. 28	4	69	28	885	44	3	5	1,505	109	6,041	3	8,696
Sept. 4	9	170	24	1,204	37	15	0	691	74	3,785	2	6,011
Sept. 11	10	81	0	776	42	25	1	1,241	107	3,559	1	5,843
Sept. 18	3	66	64	1,195	46	9	1	3,293	85	3,205	5	7,972
Sept. 25	0	48	64	1,303	47	9	0	1,102	4	4,980	7	7,564
Oct. 2	0	82	12	1,643	101	0	1	217	52	4,904	0	7,012
Oct. 9	0	39	21	1,308	168	3	0	1,527	41	3,533	8	6,648
Oct. 16	0	118	101	1,306	182	2	1	940	26	3,903	1	6,580
Oct. 23	0	113	24	1,249	354	0	1	1,664	47	3,118	0	6,570
Oct. 30	0	2	164	845	333	5	108	408	15	1,512	0	3,392
Nov. 6	8	78	32	481	330	7	0	208	18	1,811	0	2,973
Nov. 13	0	69	20	1,157	164	3	14	66	73	1,272	0	2,838
Nov. 20	0	0	11	1,426	51	0	12	0	75	459	0	2,034
Nov. 27	0	8	446	753	6	0	16	0	0	367	0	1,596
Dec. 4	0	8	17	661	1	0	0	0	2	534	0	1,223
Dec. 11	0	56	124	419	0	0	6	0	7	347	0	959
Dec. 18	------	1	20	219	------	------	------	0	0	78	------	318
Dec. 25	------	24	0	170	0	0	------	0	0	34	------	228
Dec. 31	------	2	0	194	0	0	------	0	0	128	------	324
1937												
Jan. 8	------	0	0	427	0	0	------	0	0	411	------	838
Jan. 15	------	0	0	790	0	0	------	0	0	120	------	910
Jan. 22	------	0	0	979	1	0	------	0	0	116	------	1,096
Jan. 29	------	0	0	1,017	1	0	------	0	0	28	------	1,046
Feb. 5	------	0	0	1,052	2	0	------	0	0	14	------	1,068
Feb. 12	------	0	0	900	0	0	------	0	0	34	------	934
Feb. 19	------	0	0	851	0	0	------	0	0	45	------	896
Feb. 26	------	0	1	770	1	0	------	0	0	205	------	977
Mar. 5	------	0	0	722	0	0	------	0	0	326	------	1,048
Mar. 12	------	0	0	644	0	0	------	0	0	370	------	1,014
Mar. 19	------	2	0	627	0	0	------	0	0	395	------	1,024
Mar. 26	------	0	0	937	0	------	------	0	0	469	------	1,406
Apr. 2	------	27	0	870	0	------	------	0	0	252	------	1,149
Apr. 9	------	8	0	1,155	0	------	------	0	0	417	------	1,580
Apr. 16	------	84	11	986	0	------	------	0	0	480	------	1,561
Apr. 23	------	0	5	1,299	0	------	------	0	0	790	------	2,094
Apr. 30	------	9	0	1,076	0	------	------	0	0	1,726	------	2,811
May 7	------	32	0	267	0	------	------	0	0	2,005	------	2,304
May 14	------	4	------	496	5	------	------	0	0	1,913	------	2,418
May 21	------	30	------	736	55	------	------	13	------	1,780	------	2,614
May 28	------	19	------	1,156	53	------	------	45	------	2,133	------	3,406
June 4	------	47	------	970	25	------	------	123	------	1,950	------	3,115
June 11	------	3	------	1,014	41	------	------	542	------	2,282	------	3,882
June 18	------	13	------	1,079	15	------	------	299	------	1,707	------	3,113
June 25	------	33	------	960	86	------	------	415	------	1,592	------	3,086
Total July 3, 1936, to June 25, 1937	181	1,560	1,223	45,829	2,329	139	186	22,706	1,025	125,134	73	200,385

CONTROL WORK IN THE SOUTHWESTERN STATES

The program was extended to the Southwestern States during June 1936, after the spring shearing of sheep and goats was completed. At that time screwworms were distributed over the western half of Texas and in the southern portions of other Southwestern States. In Texas the control work from June to December, inclusive, served gradually to reduce the rate of occurrence of infestations, which are shown as follows for the different months as averages among 100,000 animals; June 1,256, July 1,316, August 872, September 639, October 687, November 401, and December 195. This gradual reduction was in strong contrast to the outbreak of 1935, when an estimated 3,245,297 cases caused

a loss of about $10,000,000 in Texas. It is believed that normally the annual infestation in Texas is about 1,000,000 cases, and that the weather during 1936 was somewhat more favorable for screwworms than during a normal year. There were no extensive droughts and there seemed to be sufficient rainfall to keep wounds soft and attractive for screwworm flies, but not enough to result in drowning of immature stages in the soil. The cases in 1936 occurred at the average rate of 827 among 100,000 animals, and were estimated at 573,396 on the basis of 125,134 reported infestations. It seems conservative to attribute the difference between this estimate and that of a normal infestation to results of screwworm control work. In addition to a reduction in the number of cases, there was also a reduction in the mortality among infested animals. During 1935 the death rate was estimated at 14,732 among 100,000 animals, and in 1936 the mortalities were at an average rate of 9,410 among 100,000 infested animals. They are still high enough to emphasize the need for adopting better methods of treating animals, and especially is this true for cases occurring in sheep and goats.

In other Southwestern States control work started during June and some educational phases were continued through the winter months. From June to December, inclusive, the following were the average rates of infestations among 100,000 animals: Arizona 262, California 75, New Mexico 161, and Oklahoma 212. The infestations in all of these States were at the rate of only a fraction of 1 percent of the animal population. There was a wide variation in the mortality rates because in areas having a low incidence of cases there is a more fixed tendency of stockmen to use undiluted stock dips or other irritating materials for killing screwworms in wounds. The average rates of animals dying among 100,000 infested animals were as follows: Arizona 2,722, California 1,076, New Mexico 3,107, and Oklahoma none.

During the period when there was a good degree of control of screwworms in Texas and other Southwestern States, the pest was able to spread and cause at least 1,025 cases in Oklahoma, about 50 in Kansas, 25 in Missouri, about 100 in Illinois, and approximately 1,000 in southwestern Tennessee. These figures represent cases occurring during a dry year, in many of these areas, and a reduction from reports of the previous year, when there were about 30,000 cases in Kansas, 1,000 in Iowa, and 6,000 in Illinois. During 1936 workers in stockyards at different places examined animals and sent in specimens for identification. The following collections of primary screwworms were made: At Kansas City, Mo., 10; at East St. Louis, Ill., 39; at Kaplan and Church Point, La., 3; at New Orleans, La., 10 (of 59 cases); and at Nashville, Tenn., 1. These records show that there is an annual danger of introducing screwworms into uninfested States.

PREVENTION AND SHEARING

In the sheep- and goat-breeding area of southwestern Texas screwworms are normally present when the spring shearing begins, and they are able to spread rapidly across the area during the period required for shearing operations. In the spring of 1937 supervisors were assigned to several counties so that they could work among owners of sheep, advising them of the importance of treating shear cuts. The owners were visited in advance of shearing, and screwworm control workers urged that all shear cuts be treated with pine-tar oil to prevent infestation, and that animals having severe injuries be kept in holding pastures and treated until healed. This procedure did not prevent spread of the screwworms across the sheep- and goat-breeding area but it was most helpful in maintaining a low screwworm population. From June 20 to December 31, 1936, the average infestation in the sheep- and goat-breeding area was at the rate of 882 cases among 100,000 animals. Following special work in this area the average infestation in Texas for June 1937 was only 341 cases among 100,000 animals. Injuries of sheep, such as sore mouth, pinkeye, boils, prickly-pear injuries, and those caused by rams' fighting, are not easily avoided, but many animals escaped infestation because screwworms were at a low level. In the southeastern counties of New Mexico the treatment of shear cuts reduced screwworm infestations, but in Quay County, where no special work was done, an infestation of about 2 percent of the animal population developed in the latter part of June.

SUMMARY

The screwworm control work of the year resulted in (1) reducing infestations and death losses among livestock in Texas and other Southwestern States and further reducing cases and mortalities in the Southeastern States; (2) effectively preventing the building up of large numbers of screwworms in different

southern areas; (3) detecting the presence of screwworms in advance of the gradual spread of the pest in the Southeastern States; (4) enlisting the efforts of stockmen in stamping out localized infestations in advance of the regular spread of the pest in the Southeastern States and in stockyards; (5) effectively reducing cases in the overwintering areas so as to reduce the number of parent flies in the spring and to retard development of large populations of screwworms; and (6) preventing a build-up of screwworms in shear cuts in the sheep- and goat-breeding area of Texas and in southeastern New Mexico.

INSECT IDENTIFICATION

During the year 48,999 different lots of material were received for identification, and the number of determinations made totaled 77,856, an increase of more than 20,000 over the number reported for 1936. Sixty-eight percent of the identifications were for interceptions by the Division of Foreign Plant Quarantines, 16 percent related to material submitted by the remaining divisions of the Bureau and other Federal agencies, and the balance applied to specimens received from State experiment stations, agricultural colleges, and other institutions in the United States and its territorial possessions and from numerous individuals, both in this country and abroad. At the end of the year 6,277 lots remained unfinished, this number being slightly higher than the corresponding figure for 1936. Assistance has also been given to numerous taxonomic specialists, both American and foreign, attached to educational institutions, museums, and experiment stations, in connection with the solution of problems in insect classification.

During the brief periods not required for identification work, investigations were conducted on a variety of taxonomic problems with the object of improving the classification of difficult economic groups that have been in a state of confusion. Forty-three manuscripts were completed and submitted for publication, 24 of which were published. Most of these papers are very short, but a few that are comprehensive treatments of larger groups present the results of studies that have been under way for several years and include, for example, a revision of the horseflies of the subfamily Tabaninae and one covering the mites belonging to the subfamily Tarsoneminae.

Studies, unavoidably intermittent because of the demands for identifications, have been begun on the classification of various economic groups. Following are some of the larger of these undertakings: Classification of the white grubs; revision of the wood-boring beetles of the genus *Chrysobothris;* revision of the blowflies; revision of the fruitflies of the genus *Anastrepha;* revision of the moths of the family Gelechiidae; monograph of the moths of the family Tortricidae; revision of the moths of the family Oecophoridae; classification of the New World moths belonging to the Phycitinae; generic classification of the fleas; revision of the bee genus *Osmia;* studies on the classification of chiggers; revision of the parasitic wasps of the genus *Ophion;* generic classification of the leafhoppers of the family Cicadellidae; revision of the aphids belonging to the genus *Myzus;* studies on scale insects of the genus *Asterolecanium;* and a morphological study of the male genitalia of the Hymenoptera.

FOREIGN PARASITE INTRODUCTION

Particular attention was given to the collection and importation of natural enemies of the oriental fruit moth, the pine shoot moth (*Rhyacionia buoliana* Schiff.), the larch casebearer, the hessian fly, the European corn borer, the pea weevil, the vetch bruchid, and the lima bean pod borer. The importations of fruitfly parasites into Hawaii and of parasites to be used against a variety of pests in Puerto Rico, both under special funds, have been completed.

PARASITES OF FRUIT INSECTS

Shipments of cocoons and adults of oriental fruit moth parasites from Japan and Chosen during the fall of 1936 totaled 19,335, representing 16 species. These are the same as have been imported in preceding years. During the spring of 1937 a total of 102,166 infested peach twigs were collected in Japan and 121,085 in Chosen, and the parasites contained in them, numbering 41,439, were forwarded during June.

PARASITES OF FOREST INSECTS

The field of investigation of pine shoot moth parasites was shifted from England to the Netherlands for the collection of material during May and June 1937. A total of 3,440 cocoons, comprising 8 or more species, were forwarded, and also 6,500 dead host larvae containing an estimated 100,000 *Copidosoma geniculatum* Dal.

A total of 7,100 parasites of 8 species emerged from the 102,000 larch case-bearer larvae shipped from England in 1936. The collections in 1937 were made in the Netherlands and 53,500 host cases were shipped during May.

PARASITES OF CEREAL AND FORAGE INSECTS

Attention has been given to securing two European parasites of the hessian fly for colonization in the United States. These, however, have not proved to be abundant in any section. Large quantities of infested wheat straw were set aside for parasite emergence, and 1,000 *Platygaster pleuron* Walk. and 855 *Trichasis remulus* Walk. were reared out and shipped.

Investigations of parasites of the European corn borer were limited to Italy, where collections for *Chelonus annulipes* Wesm. were made. A total of 85,000 host larvae were shipped late in 1936, and these were estimated to contain 5,500 *Chelonus* and probably a larger number of other parasites.

PARASITES OF TRUCK CROP AND GARDEN INSECTS

Extensive shipments of pea weevil parasites were made during the summer of 1936 from France and Austria. A total of 5,600 *Triaspis thoracicus* Curt. were obtained from 400 pounds of infested horsebeans shipped from France and reared out under quarantine conditions. In addition 30,000 adults of the same species were shipped from Austria. The number that reached the Pacific Northwest alive and were colonized totaled 26,500. The spring shipments of 1937 contained approximately 65,000 parasites of the same species. A portion of these are to be utilized against the vetch bruchid in the Eastern States.

Preliminary studies were made upon the parasites of the lima bean pod borer in France and Austria, and it was determined that several promising parasites occur in those countries. Small test shipments of *Microbracon piger* Wesm. and *Phanerotoma planifrons* Nees were made during the summer of 1936.

IMPORTATION OF FRUITFLY PARASITES INTO HAWAII

The exploratory work under this special project was completed late in the summer of 1936. During the 6-month period covering actual importations 2,556 adult parasites of 14 species and 68 predacious beetles of 2 species reached Hawaii alive. These originated in West Africa, Brazil, Puerto Rico, Mexico, Malaya, and India. No recoveries of these natural enemies have yet been made in Hawaii.

PARASITE IMPORTATIONS INTO PUERTO RICO

The work in Puerto Rico under special funds was completed in September 1936, since which time further activities in this line have been on a cooperative basis with the Office of Experiment Stations. The principal shipments of the year are listed in table 19.

TABLE 19.—*Shipments of parasites into Puerto Rico during the fiscal year 1937* [1]

Host	Parasite	Number shipped
Lima bean pod borer	*Macrocentrus ancylivorus* Roh	5,530
Pineapple mealybug	*Anagyrus coccidivorus* Doz	102
Do	*Hambletonia pseudococcina* Comp	88
Pink bollworm	*Exeristes roborator* F	10,300
Do	*Chelonus blackburni* Cam	19,200
West Indian fruitflies	8 species	2,600
White peach scale	*Prospaltella berlesei* How	863

[1] In addition a total of 7,500 dung beetles, of 4 species, were shipped from Texas and Hawaii.

Field recoveries of two additional species have been made during the year. The coccinellid beetles imported from Trinidad in January 1937 have apparently brought about complete control of the coconut scale in the sections where they have been colonized.

COOPERATION WITH FOREIGN ORGANIZATIONS

In cooperation with the Entomological Branch of the Canadian Department of Agriculture, and with funds provided by that department, the Bureau station at Yokohama, Japan, collected and forwarded 213,000 field-collected cocoons of *Diprion nipponica* Roh., the parasites from which will be utilized against the spruce sawfly. Arrangements were made for sending a colony of *Ephialtes examinator* F. to Canada for use against the pine shoot moth and of *Heterospilus cephi* Roh. for use against the wheat stem sawfly. The parasites and predators received from the Canadian Department of Agriculture during the year are listed in table 20.

TABLE 20.—*Parasites and predators received from Canada during the fiscal year 1937*

Host	Parasites	Number received
European corn borer	*Chelonus annulipes* Wesm	7,665
Fir bark louse (*Adelges piceae* Ratz.)	*Leucopis obscurus* Hal	569
Spruce sawfly	*Exenterus abruptorius* Thunb	2,890
Do	*Microplectron fuscipennis* Zett	500,000
Black grain-stem sawfly	*Collyria calcitrator* Grav	5,100

Through the cooperation of the different divisions of the Bureau, shipments of parasites and predators have been forwarded during the year to the countries listed in table 21.

TABLE 21.—*Shipments of parasites and predators to foreign countries during the fiscal year 1937*

Country	Host	Parasite
Argentina, Australia, Uruguay	Oriental fruit moth	*Macrocentrus ancylivorus* Roh.
Do	do	*Glypta rufiscutellaris* Cress.
Argentina, Uruguay	do	*Bassus diversus* Mues.
Do	do	*Ascogaster quadridentata* Wesm.
Costa Rica	Woolly apple aphid	*Aphelinus mali* Hald.
Egypt	Pink bollworm	*Chelonus blackburni* Cam.
Do	Cotton worm (*Prodenia litura* F.)	*Bufo marinus* L.
Mauritius	Cane grubs (*Phytalis* spp.)	*Pyrophorus luminosus* Ill.
Mexico	Woolly apple aphid	*Aphelinus mali* Hald.
Peru	Codling moth	*Ascogaster quadridentata* Wesm.
Do	Mealybugs (*Pseudococcus* spp.)	*Cryptolaemus montrouzieri* Muls.
Do	Cane beetles (Scarabaeidae)	*Bufo marinus* L.
Santo Domingo	Coconut scale (*Aspidiotus destructor* Sign.)	*Pentilia castanea* Muls.
Do	do	*Cryptognatha nodiceps* Marshall.

CONTROL INVESTIGATIONS

TESTS OF ORGANIC COMPOUNDS AND PLANT PRODUCTS AS INSECTICIDES

In the testing of organic compounds as insecticides, 56 were found that showed promise against some of the 7 leaf-eating species used for test purposes. It is expected that a number of these 56 compounds will be of value for commercial use against insect pests of crop plants. Many of them have shown no injurious effects when applied to crop plants in a preliminary way. Three hundred compounds or preparations were tested in this work, including those used in preliminary tests on mosquito larvae.

In cooperation with the Division of Drug and Related Plants of the Bureau of Plant Industry, approximately 800 preparations of plants from Puerto Rico, supposedly fish poisons, were tested for insecticidal value. Except in a few

cases, only those preparations from plants containing rotenone showed indications of effectiveness as insecticides. Tests were also made of several hundred samples of American-grown pyrethrum and preparations from roots of *Cracca virginiana*. These were tested by the biological assay method in connection with plant breeding or selection work under way in the Bureau of Plant Industry. This method makes possible the rapid determination of the insecticidal efficiency of a preparation, being about 20 times as rapid as chemical analysis.

A method of evaluating concentrated fly sprays was developed.

NICOTINE AS A FUMIGANT

In the work with nicotine as a fumigant it has been shown that this insecticide is more effective when used under dry than under humid conditions as formerly supposed, though the humidity at which the insects are held after fumigation apparently has little effect on the efficiency of the treatment. Eight kinds of aphids were used in these tests, and nine other species of insects, including four species of thrips, the housefly, adult codling moths, and silkworm larvae. Much variation in resistance was found, the housefly being very resistant and the aphids very susceptible. The bean aphid was killed with a concentration of two-thirds of a part per million; the adult codling moths and the silkworm larvae were almost as susceptible. Body size and susceptibility of insects to nicotine vapor are not directly related.

A gasoline-driven unit which atomizes nicotine solutions and circulates the fumigant has been tested for aphid control in greenhouses. Toxicity tests show that where approximately the same concentrations of nicotine vapor are used, the cost for material for treatment by this method is about one-half that of some of the other well-known methods. It is planned to put this method on a commercial basis as soon as possible.

In physiological studies on the effect of nicotine on insects it has been shown that the primary effect of nicotine is on the nervous tissue of the insect's heart mechanism; and in comparing two insects it was indicated that in the southern armyworm, where heart nerves have not been found, the effect was much less apparent than it was in the roach, where heart nerves are present.

RECORDING VOLUME AND AMPLITUDE OF THE INSECT HEARTBEAT

In this work a method was devised for amplifying the heartbeat of an insect, and recently a special cardiographic camera has been developed for making permanent records of the volume and amplitude of the insect heartbeat. With this apparatus it is possible to study the effect of various types of insecticides or pharmacological compounds on the insect heart and make accurate records of their effect so that comparisons can be made. This apparatus opens a new field of investigation, and the results of this work will lead to a better understanding of the effect of insecticides on insects.

DIGESTION AND ABSORPTION IN SOUTHERN ARMYWORM

In studies on digestion and absorption in the southern armyworm, it has been found that pyrethrum, which is an excellent insecticide against many insects, loses its toxicity in the digestive tract of the larvae, whereas rotenone, the main toxic constituent of derris root, passes through the digestive tract with toxicity against mosquito larvae practically unchanged. Incubation of these insecticides with various tissues and organs taken from the larvae results in little or no decrease of toxicity in the rotenone but an appreciable detoxification of the pyrethrum, as tested against mosquito larvae. This helps explain the ineffectiveness of these insecticides against this insect and indicates an explanation of its behavior in other cases. A chemical analysis of the blood of the southern armyworm has been made as a preliminary to further tests on the absorption of food products, insecticides, or other substances from the alimentary tract. About 30 blood constituents were quantitatively determined. It is of interest to note that while copper is found in appreciable quantities in both organic and inorganic combination, apparently no oxygen-transporting or respiratory pigment is present in the blood of this insect. This is contrary to the assumption with regard to certain other insects.

REFRIGERATOR CARS AS FUMIGATION CHAMBERS

The ordinary refrigerator car has been shown to be a very effective fumigation chamber, and fumigations of vetch seed against the vetch bruchid, applied in the car under commercial conditions, have given a complete kill. As a matter of fact, the cars were found to be more satisfactory than many fumigation chambers, though good results are obtained in tight vaults.

METHYL BROMIDE AS A FUMIGANT

In cooperation with other divisions of this Bureau, methyl bromide, which has only recently been suggested as a fumigant, has been tested against various insects and with various types of plant products, especially fresh fruits and vegetables and greenhouse plants. It has been used with lima beans, eggplants, cucumbers, green string beans, sweetpotatoes, cantaloups, peppers, tomatoes, and potatoes, in concentrations sufficient to kill the Japanese beetle in the packages, without injury to the product.

Methyl bromide has been tested on loads of 25 bushels or more of green string beans packed in hampers and was found to be effective in killing the Japanese beetle at the center of the package at concentrations of 1½ to 2 pounds of methyl bromide per 1,000 cubic feet of space without injury to the beans. In experimental treatments a dosage of 3 pounds has frequently been used without injury.

Eight different varieties of strawberry plants with soil on roots, packed in crates ready for shipment to market and infested with larvae of the Japanese beetle, were fumigated with methyl bromide. In all cases complete mortality of the larvae was obtained, and the plants grown in the field with appropriate checks showed no evidence of injury. This treatment will materially reduce the cost of disinfesting millions of strawberry plants, which was formerly done by inspecting plants one by one and removing the beetles by hand.

In preliminary experiments with methyl bromide in the fumigation of peach trees for controlling the oriental fruit moth there was complete mortality of the insect with no apparent injury to the nursery stock. Thirty-one greenhouse plants were fumigated with a dosage of 3 pounds of methyl bromide per 1,000 cubic feet without injury, with practically a complete kill of three varieties of aphids, the common red spider, one species of thrips, two species of mealybugs, and immature stages of the southern armyworm. Methyl bromide gives promise of being a good greenhouse fumigant at a temperature of 65° F.

Special apparatus has been devised for introducing methyl bromide and other fumigants into refrigerator cars for the fumigation of carloads of produce without loss of the gas and with a good mixing of the gas in the car.

LOW-TEMPERATURE TREATMENT OF GRAPES FOR MEDITERRANEAN FRUITFLY

During the year it was shown that the low-temperature treatment for the Mediterranean fruitfly could be applied by cooling the fruit in a pre-cooling plant on shore and holding it at a temperature of 34° F. or slightly below that temperature for the required 12 days in the hold of a ship in transit. In this work the fruit (grapes) was cooled at Capetown, South Africa, and loaded on a ship, and the remainder of the treatment was applied en route to Southampton, England. Temperature-measuring instruments in the hold of the ship made possible an accurate determination of the temperature of the fruit by an observer who accompanied the shipment. By this method the importation of grapes from countries in which the Mediterranean fruitfly is found can be safely made to the United States, provided the conditions are such that treatment is properly applied.

INSECTICIDE INVESTIGATIONS

The only change in set-up of the investigations on insecticides since the last annual report was the closing of the laboratory at Wooster, Ohio. The study of the characteristics and effectiveness of oil emulsions which was under way there was discontinued, and the chemist concerned was transferred to Beltsville, Md., where he is developing stickers for use with phenothiazine, nicotine-peat, and other organic insecticides which have been found insufficiently adhesive of themselves.

Forty-six articles were published, mostly in journals outside the Department. Eight patents on various new insecticides and methods of making them, and on new washing solutions for removing insecticidal spray residues from apples, were granted members of the Division. The monthly review of United States patents relating to pest control was issued regularly throughout the year and was sent to 1,133 American and 233 foreign entomologists.

CHEMICAL INVESTIGATIONS ON INSECTICIDAL PLANTS (TOBACCO, DERRIS, PYRETHRUM, ETC.) AND THEIR CONSTITUENTS

Studies on the chemistry of pyrethrum flowers have been continued. Pyrethrum flowers are used in the manufacture of household insecticides intended for combating flies, fleas, mosquitoes, roaches, etc., in cattle sprays, and in dusts for the treatment of celery, cabbage, and numerous other crops. From 10,000,000 to 15,000,000 pounds of this important insecticide are imported yearly, and it is highly desirable to know more about its chemistry. One of the objects of these studies is the isolation of pure pyrethrin I and pure pyrethrin II in order that their relative insecticidal efficacies can be studied. Methods were worked out for obtaining the semicarbazone of pyrethrin II in pure form, but no scheme could be found for hydrolyzing this compound to yield pure pyrethrin II. The semicarbazone of pyrethrin I, on the other hand, is always obtained quite impure, and it was finally determined that it is always accompanied by some of the semicarbazone of pyrethrin II, and by the semicarbazone of pyrethrolone esters of palmitic and linoleic acids. Attempts to regenerate pyrethrin II from pyrethrolone and chrysanthemum dicarboxylic acid yielded a product not identical with natural pyrethrin II. It was found further that the spatial configuration of pyrethrolone is the same whether obtained from pyrethrin I or pyrethrin II, and that the pyrethrins can be cleaved by catalytic hydrogen with the formation of dihydrojasmone, a perfume. Extensive studies were carried out on the nature of the side chain of pyrethrolone, which is important because of the marked specificity of the pyrethrins to insects. The exact position of the double bonds was not demonstrated conclusively, but the evidence favors an allene system rather than a conjugated system.

The question of the presence of nicotine and other alkaloids in species other than *Nicotiana tabacum* was further investigated. It was discovered that *N. sylvestris* contains l-nornicotine. This plant is the only known source of this alkaloid, which is more toxic than nicotine and hence of insecticidal interest. A study of *N. debneyi* revealed the presence of anabasine and nicotine. It became necessary to study the separation of nicotine from the other alkaloids, and a method involving distillation of aqueous solutions was developed for separating anabasine and nicotine with great accuracy. The preparation and properties of nicotine-peat were studied further, 1,200 pounds being prepared in the Department's laboratories for field use of the Bureau during the present season. The greater stability of nicotine tannate over nicotine sulphate was demonstrated by residue studies, and a rather rapid decomposition of nicotine by air was demonstrated. Two articles describing a gravimetric microchemical method for determining small amounts of nicotine were published. In addition, for a study of the evolution of nicotine from dusting mixtures containing it, there was developed another new microchemical technique involving titration of the nicotine with silicotungstic acid, the end point being recognized as the point of maximum turbidity as measured by a photoelectric device.

The question of rotenone and plants bearing it was again given considerable attention. The work of devising a satisfactory method of determining rotenone was brought to conclusion; the crystallization procedure was described in a published article, and the details of the extraction procedure are now in manuscript form. In addition, a possible new analytical procedure, involving a chemical estimation of the rotenone rather than its separation by crystallization, was developed and is being tested. The solubility of rotenone was determined in 53 commercial organic solvents not heretofore reported upon. The physical properties of the complex which rotenone forms with carbon tetrachloride were investigated, because of the importance of this compound in the analysis of derris and cube.

The study of the retardation of the decomposition of derris was continued. Out of 116 spray combinations studied in the laboratory, the 15 that showed some promise from the chemical point of view were prepared for careful insecticidal testing during this summer.

Certain other insecticidal plants and their active constituents were studied. The active material in quassia wood was found to contain two isomeric materials called quassin and neoquassin, and much information was obtained toward determining their structures. Another isomeric material, picrasmin, was obtained from picrasma wood, and its close relationship to quassin demonstrated. The study of *Haplophyton cimicidum* was concluded, without any very definite results. An active principle designated helenalin was obtained from *Helenium autumnale* and another one called tenulin from *H. tenuifolium*, and both materials were studied as to structure.

CHEMICAL INVESTIGATIONS TO DEVELOP SNYTHETIC ORGANIC INSECTICIDES

Over 100 organic compounds were synthesized and sent out for insecticidal testing, mainly against codling moth larvae, mosquito larvae, cabbage-infesting caterpillars, the tobacco hornworm, and the Japanese beetle. Several showed sufficient activity to warrant the filing of patent applications covering them and the classes to which they belong. One patent covering aryl thioxins (phenothioxin) was obtained.

The attempt to better adapt phenothiazine to field work was continued. Its high toxicity to codling moth larvae is admitted, but its application is rendered difficult by its poor wettability, and the deposits do not adhere very well. Laboratory tests have shown that a heavier deposit of phenothiazine is obtained when it is mixed with calcium chloride and soap, which produce a sticky calcium soap capable of holding the phenothiazine. The conditions of exposure which lead to the decomposition of phenothiazine were studied.

CHEMICAL INVESTIGATIONS ON THE REMOVAL OF SPRAY RESIDUE

The removal of lead arsenate from apples was again studied in detail at the Washington, D. C., laboratory. Fruit of several varieties, and sprayed in several ways, was washed with various solutions at several temperatures and in three kinds of machines. A total of 502 samples were analyzed. Residues were lighter in general than in the previous year, and were more easily removed. A varietal effect on ease of removal was evident, and delay after picking caused trouble. The effect of mineral oil in building up of deposit, and in the hindering of washing, was again demonstrated, as was the superiority of the brush-flood machine. A study of 48 of the samples failed to show any significant change in the ratio of lead to arsenic, previously claimed by other investigators. At the Yakima laboratory 132 samples of apples coming from spray plots that had received cryolite were analyzed for fluorine residues, and by the use of the analytical methods developed by the Food and Drug Administration it was demonstrated for the first time in our work that these residues can be satisfactorily removed by efficient washing equipment. At the Vincennes, Ind., laboratory it was demonstrated that lead arsenate residues from first-brood cover sprays are more difficult to remove than those from the second-brood sprays, regardless of the quantity of residue present at harvest, and that the use of adhesives with or following lead arsenate sprays complicates residue removal.

The results of the study of the lead content of chewing tobacco and snuff, presumably residues from the insecticidal dusting of tobacco, were published.

A method of estimating phenothiazine spray residues was developed. It was shown at Yakima that the spray procedures giving good control of codling moth larvae were those that deposited over 20 micrograms of phenothiazine per square centimeter of apple surface, and that such residues can be easily removed by washing. Also, it was shown that phenothiazine residues decompose somewhat from exposure to heat and light, a change that seems to be accelerated by oils, waxes, and finely divided materials such as bentonite.

A method of determining boron in rice dusted with borax was worked out, and the treated rice was shown to contain from 5 to 200 parts of boric acid per million. It was demonstrated that the removal of the hull in the polishing process also removed the greater part of the residue.

A microchemical method for determining antimony was developed to the point where it is suitable for the study of the spray residues resulting from the use of tartar emetic against fruitflies. It resembles the Gutzeit method for arsenic, and determines from 25 to 150 micrograms of antimony. Inci-

dentally, certain features of the Gutzeit method for arsenic were improved, and they may be useful in further improving the antimony method just mentioned.

CHEMICAL INVESTIGATIONS TO DEVELOP INORGANIC INSECTICIDES

Last year's report described the work on commercial calcium arsenate which showed how complex this important insecticide is, and how that complexity is the result of failure to reach equilibrium in the manufacturing process. This year attention was devoted to the development of a method of preparing calcium arsenate so that equilibrium will result in every case, and the composition of the resulting product therefore be predictable from the proportions of lime and arsenic acid used. It was found that by atomizing the acid into the lime slurry while the latter was violently agitated, the local excesses responsible for disturbed equilibria were prevented, and the finished product turned out every time to be what the phase-rule studies had indicated it should be. It is thought that this method can be adapted to commercial manufacture.

A survey of about 40 of the many brands of dusting and wettable sulphurs on the insecticide market was undertaken and the determination of their physical properties almost completed. Complete particle-size analysis was made on all of them, and, as in the case of the calcium arsenates and paris green already reported on, great differences were found among the various brands. This work is part of the general program of studying the relation between particle size and insecticidal efficacy of dusting and spraying materials. A so-called air classifier was obtained and set up, and with this machine considerable quantities of paris green of definitely different particle sizes have been prepared and offered to cooperating entomologists for toxicity tests.

Much work was done on lead arsenate in relation to its use as a soil insecticide for Japanese beetle grubs. A new and shorter method of sampling treated nursery plots was worked out, and nearly 1,000 samples were analyzed preparatory to retreatment. The uniformity of deposits obtained on grass plots was determined, and a start made on the development of a method of chemical analysis for judging the toxicity of a treated soil rather than merely its arsenic content. The effect of various materials in counteracting the deleterious action of lead arsenate in soil on plants growing therein was studied, and promising results were obtained with certain iron compounds, such as bog iron ore and a commercially available chemical byproduct, ferric hydroxide.

Some work was done on the homologs of paris green, and the possibility demonstrated of preparing such greens directly from vegetable, animal, and fish oils instead of from the acids they contain.

CHEMICAL INVESTIGATIONS ON FUMIGANTS FOR CONTROL OF INSECT PESTS

Much of the work done at Whittier, Calif., on the fumigation of the California red scale on citrus was devoted to the betterment of experimental procedure, and various distinct improvements were worked out. First, the concentration of hydrocyanic acid and the length of exposure necessary to give practically 100-percent kill was determined to be 2.1 milligrams of hydrocyanic acid per liter for 40 minutes. Then a procedure was worked out for preconditioning and postconditioning the experimental fruit under certain definite conditions of temperature and humidity so that the scales can be expected to be in a much more uniform state of activity when fumigated. As a result of this, experimental figures can be duplicated now much better than ever before.

In connection with the work on the fumigation of stored cereal products which is under way at the Manhattan, Kans., laboratory, advances were made in the technique of fumigation in vacuum vaults. In addition, studies were made of the retention of hydrocyanic acid by flour and by rice, and of the dissipation of the hydrocyanic acid with the lapse of time and upon boiling. Finally, the effect of various fumigants upon popcorn, as evidenced by the bulk of popped corn produced, was studied. Hydrocyanic acid appears to have no effect, carbon disulphide lowers the bulk at the higher concentrations, and ethylene dichloride has a pronounced effect which lessens with the time of keeping the fumigated corn before popping.

A study of the fumigation of vegetables with methyl bromide was undertaken. So far, attention has been devoted to the development of methods of analysis, with special reference to one vegetable, string beans.

Paradichlorobenzene is used as a soil fumigant in combating Japanese beetle grubs in nursery stock, and for its effective use the concentration in the treated soil must be watched. No method for its estimation was available, but one was worked out which appears quite satisfactory for use with soils containing water, peat, leafmold, or cow manure.

CHEMICAL INVESTIGATIONS ON OILS AND OIL EMULSIONS

The principal objective of this project was the comparison of the insecticidal value of certain vegetable oils, namely, peanut, corn, cottonseed, pine, and orange oils, with a commonly used petroleum oil. In tests against mealybugs it was found that the first three were about as good as petroleum oil, and under some conditions might be better, as for instance when used at large dosages. In tests of the same oils against overwintering eggs of the scurfy scale, it was found that the drying property of each oil was an important index of the toxicity, quick drying resulting in lesser efficacy. In the study of the effect of adding toxicants to the oils, it was found that nicotine and nicotine-betanaphthol improved notably the action of petroleum oil, but did not similarly aid corn oil. Pine oil and orange oil were found to be poor because they volatilized too rapidly to be effective insecticides and were quite active in injuring the plants. Of all the additional toxicants tried, the nicotine and betanaphthol combination seemed particularly worthy of further study.

This project was discontinued near the end of the year, and the personnel transferred to Beltsville for work on the development of stickers.

CHEMICAL INVESTIGATIONS ON ACCESSORY MATERIALS FOR USE WITH INSECTICIDES

An extensive investigation of the wetting and spreading properties of mixtures of various fatty acids with sodium hydroxide and with sodium carbonate was carried on, in order to better understand the action of soaps, which are so often used as emulsifiers in oil emulsions and as wetters and spreaders for other spray materials. It was demonstrated that the surface activity increases fairly regularly with increase in molecular weight of the fatty acid, thus following the properties of foaming and detergency. The spreading power of solutions made with sodium hydroxide was found to be quite sensitive to changes in the acid/base ratio, whereas solutions prepared from sodium carbonate were not, indicating the possibility of stabilizing the action of soaps by the use of the carbonate.

A special study was made of triethanolamine oleate, because of its recent popularity in published spray recommendations. It was found to be a generally effective wetting agent. A somewhat similar study was made of solutions of trimethyl benzylammonium oleate, which has recently become commercially available, and it was found to resemble closely sodium oleate.

A study was made of wetters and adhesives for use with phenothiazine, nicotine-peat, and derris.

TESTS TO DETERMINE TOXICITY OF NEW INSECTICIDAL COMPOUNDS, USING GOLDFISH

The principal work of this project was directed toward the finding of possible relationships between toxicity and chemical constitution, as an aid to the project of developing synthetic organic insecticides. To this end the three isomeric tolyl mercaptans or thiocresols were thoroughly studied. When compared at the points of minimum product of time and concentration, the ortho isomer was found to be 1.19 and the para isomer 2.19 times as toxic as the meta compound, these relationships being practically the same as found previously for the corresponding cresols. The mercaptans are from four to eight times as toxic as phenol, but only one-fortieth to one eighty-fifth as toxic as rotenone. The replacement of the oxygen atom of the cresol molecule with sulphur therefore results in a fourfold increase in toxicity, as compared with a sevenfold increase in changing from phenol to thiophenol.

A study similar to the above was begun with the nitro phenols. Preliminary results show the para isomer to be decidedly more toxic than the ortho compound, as was the case with both the cresols and the thiocresols.

CHEMICAL ANALYSIS OF MISCELLANEOUS COMPOUNDS TESTED AS INSECTICIDES

About 350 samples of insecticidal materials used by other divisions of the Bureau were analyzed as usual to insure that the tests were being made with compounds of normal composition. This led to several investigations of analytical methods, such as a new method for determining wood phenols in tar oils, and the adaptation of the red color test for rotenone to actual analysis of samples received. In the latter case it was found that the color test is fairly well correlated with the rotenone content of powdered roots and hence can serve as at least a rough method of approximation. Ninety-five samples of tobacco were analyzed for the Agricultural Adjustment Administration to guide them in the disposition of large stocks damaged by water in the floods of last spring. A special study of the weathering of codling moth bands, involving 150 samples, was made for the Division of Fruit Insect Investigations. Five hundred and twenty-six samples of leaves from forest trees sprayed from an autogiro with lead arsenate and calcium arsenate were analyzed for the Division of Forest Insect Investigations to guide them in regard to questions of distribution and spread. An extended investigation of the process of soaking gladiolus corms in mercuric chloride solutions for the control of thrips was made in cooperation with the Division of Truck Crop and Garden Insect Investigations, and it was demonstrated that when the usually recommended procedure is used about one-half of the mercury chloride is absorbed by the corms. This shows that the usual practice of employing the same solution for more than one lot of corms may not kill all the insects, and that a different procedure must be developed.

TRANSIT INSPECTION

A heavier movement of nursery stock than has been experienced in recent years was reported by transit inspectors in the spring of 1937 at several of the cities where such shipments are inspected while passing through the railway transfer points. Inspection was carried on at 18 of the more important railway centers of the United States throughout the year, or at nursery-stock shipping seasons. The regular force of 16 full-time inspectors was augmented by the assistance in the spring and fall of from 18 to 25 men from other projects of the Bureau, and from 12 to 15 State inspectors. Such action on the part of the States indicates considerable stimulation of interest in recognition of the value of transit inspection in preventing the entry of pests in shipments from the quarantined areas. During the year 1,250,000 package shipments and over 250,000 carloads of nursery stock and other restricted materials were inspected for compliance with certification requirements of Federal quarantines relating to interstate movement. In addition, 547,000 waybills were checked to determine whether the shipments carried materials the movement of which is restricted by these quarantines. There were 2,678 violations of such quarantines intercepted, consigned to points in every State in the Union, the District of Columbia, and Canada. Most of these shipments were returned to the consignors. During the year 90 live adult Japanese beetles were found at midwestern points in the inspection of carloads of produce from the heavily infested area.

The rule of turning back shipments found to be moving in violation of Federal interstate plant quarantines was modified in the spring of 1937 with respect to quarantines relating to the Japanese beetle and the gypsy moth and browntail moth, and a new inspection service was authorized. It has been found that the contents of certain types of shipments, including small home packages free from soil, can be readily examined at the terminals to determine whether they are free from such pests. Transit inspectors have accordingly been personally authorized to inspect specified types of shipments, when practicable, and, if found free from the pest concerned, to affix the required certificate and allow the shipment to proceed. This service, it is believed, in no way weakens the effectiveness of the restrictions established to prevent the spread of pests. The consignors, usually persons unaware of the regulations, are notified of violations committed, and any repetition of failure to obtain the inspection before shipping is met by turning back the second shipment.

Incidental to the regular activities of enforcing Federal domestic quarantines, there were reported to the enforcing organizations other apparent violations which came to the attention of transit inspectors, including 130 relating to intrastate quarantines pertaining to pests on account of which Federal quarantines have been established, several relating to foreign plant quarantines, 3 relating to the Insect Pest Act; approximately 500 relating to postal regulations applying to plant shipments, and many apparent infringements of State nursery inspection regulations.

Knowledge of routing and distribution of shipments, not only in the vicinity of the terminal worked but also at the transfer points over the main connecting lines, is required of transit inspectors. Such wide familiarity with transportation details on the part of the Cincinnati inspector proved invaluable to the public welfare in the 1937 flood disasters, when his services were requested by the local relief agencies, and he was assigned to direct the routing of emergency food shipments into the city and to assist the health authorities in determining the contents of some 900 railway cars caught in the yards, and to assemble the 135 cars of perishables for inspection and disposition.

Table 22 gives data pertaining to shipments intercepted at transit inspection points.

TABLE 22.—*Shipments of nursery stock and other articles intercepted in violation of Federal plant quarantines at transit inspection points, fiscal year 1937*

Station	Shipments intercepted in apparent violation of quarantines relating to—								
	Black stem rust	Gypsy moth and brown-tail moth	Japanese beetle	Pink bollworm	Thurberia weevil	White-pine blister rust	Mexican fruitworm	Dutch elm disease	Total
Atlanta			5				2		7
Boston		68	82			2	1		153
Chicago	6	100	400	3	2	26	94		631
Cincinnati		2	18			3	9		32
Detroit		23	13				1		37
Indianapolis		3	7				4		14
Jacksonville		2	77						79
Kansas City		3	52	1		8	29		93
New York		292	352			13	3	1	661
Omaha and Council Bluffs	2	11	131			7	4		155
Philadelphia		28	220	2		4	19		273
Pittsburgh	5	3	182			31	15		236
St. Louis		1	26				57		84
St. Paul and Minneapolis		3	22	1		16	29		71
Springfield, Mass		138	13						151
Washington		1							1
Total	13	678	1,600	7	2	110	267	1	[1] 2,678

[1] The total number of violations represents 2,611 shipments, of which 57 were in violation of 2 quarantines and 5 were in violation of 3 quarantines.

TERMINAL INSPECTION OF MAIL SHIPMENTS

The States of California, Montana, and Mississippi availed themselves, during the year, of the provisions of Act No. 643, of June 4, 1936, amending the law relating to the terminal inspection of parcel-post shipments of plants and plant products. These States have established the procedure, through Federal channels, of turning back parcel-post shipments found to be in violation of certain State plant quarantines.

The terminal inspection procedure which has been in effect for several years, and which provides for turning back or disinfecting infested shipments, continues to be maintained in Arizona, California, the District of Columbia, Florida, Hawaii, Idaho, Louisiana, Mississippi, Montana, Oklahoma, Oregon, Puerto Rico, Utah, and Washington.

CONVICTIONS AND PENALTIES IMPOSED FOR VIOLATIONS OF THE PLANT QUARANTINE ACT

The following convictions and penalties imposed for violations of the Plant Quarantine Act were reported to the Bureau during the year:

Gypsy moth and brown-tail moth quarantine: One conviction, with fine of $25.

Japanese beetle quarantine: Two convictions, with fines aggregating $75.

Quarantines affecting Mexican plants and plant products: Fines aggregating $452.85 were imposed by customs officials on the Mexican border against 436 persons caught attempting to smuggle in from Mexico prohibited plants and plant products.

FOREIGN PLANT QUARANTINES

The Division of Foreign Plant Quarantines is engaged in the enforcement of quarantines and regulatory orders of the Department prohibiting or restricting the entry of various plants and plant products into the United States and, in addition, the enforcement of such domestic quarantines as affect the movement of plant material between the Territories of Hawaii and Puerto Rico and continental United States. During the year 20 foreign plant quarantines and regulatory orders, 8 domestic plant quarantines, and 4 miscellaneous regulatory measures were enforced.

Plant-quarantine inspectors and collaborators are stationed at the more important ports of entry and at points distributing foreign mail and work in close cooperation with employees of the Treasury and Post Office Departments.

Detailed information on the various plant quarantines administered by the Bureau is available in other publications. Of particular interest in connection with foreign plant quarantines are the following changes:

Quarantine No. 5, the Mexican fruitfly quarantine, which prohibited the entry into the United States from Mexico of certain known host fruits of the Mexican fruitfly, was lifted, effective December 1, 1936, and the control of entry of the fruits in question thereby became subject to the provisions of Quarantine No. 56, the fruit and vegetable quarantine. The only effect of this action is that certain fruits from Mexico formerly prohibited entry may now be entered frozen or in a processed state under the provisions of Quarantine No. 56.

Effective September 1, 1936, Quarantines Nos. 7 and 20, which had prohibited the entry of five-needle pines, currants, and gooseberries from Europe, Asia, Canada, and Newfoundland, and other pines from Europe, were lifted. The entry of the material formerly covered by these quarantines automatically became subject to the restrictions of the Nursery Stock, Plant, and Seed Quarantine, No. 37. A limited amount of such material was imported under that quarantine, under conditions that would not contribute to the further spread of the blister rust in this country.

Notice was given on July 20, 1936, that, effective August 1, 1936, the entry of seeds of *Lathyrus* and *Vicia* would be subject to the restrictions affecting the entry of other seeds covered by regulation 3 of the Nursery Stock, Plant, and Seed Quarantine, No. 37. Under the provisions of this notice 3,671,709 pounds of vetch seeds were imported from 6 countries and 1,802 pounds of sweet pea seeds from 5 countries.

On December 15, 1936, the entry of narcissus bulbs became subject to the restrictions of regulation 3 of quarantine No. 37, whereas they had been imported, since January 1, 1926, under the provisions of regulation 14 of the same quarantine. The principal effect of this change is to remove the quantity and utilization limits which applied to the importations of these bulbs under the provisions of regulation 14. This modification became effective after the close of the commercial importing season and most of the narcissus bulbs, elsewhere given as imported, entered under regulation 14.

Quarantine No. 56 was amended to provide for the entry of fruits and vegetables which have been treated, or are to be treated, under the supervision of a plant-quarantine inspector of the Department in a manner deemed adequate to eliminate any pest risk. This provision applies especially to frozen fruits and vegetables and to fruits and vegetables subject to low-temperature sterilization.

Effective December 1, 1936, the regulations governing the importation of potatoes into the United States were amended to provide for the entry of potatoes from the entire northern territory of Baja California, Mexico, through both Calexico and San Ysidro, and to eliminate the provision for the unrestricted importation of foreign potatoes into the Territory of Hawaii for local use. Previously, entry of potatoes from Baja California had been limited to those grown in and shipped from the Imperial Valley of the northern territory of

Baja California through Calexico only; and the entry of foreign potatoes had been allowed into Hawaii without restriction when imported for local use.

Effective March 6, 1937, importation of potatoes from Latvia was authorized in accordance with the potato regulations.

MARITIME-PORT INSPECTION

SHIP INSPECTION

Ships from foreign countries and also those from Hawaii and Puerto Rico are inspected promptly upon arrival for the presence of prohibited and restricted plant material in ships' stores, passengers' and crews' baggage, quarters, and in cargo.

The inspection at ports in California, Florida, Hawaii, and at certain ports in Puerto Rico has been performed by State and Territorial officials serving as collaborators of the Bureau of Entomology and Plant Quarantine.

A record by ports of the ship inspection appears in table 23. Following the policy adopted last year, the number of ships carrying restricted plant material is not shown. In previous reports both prohibited and restricted plant material had been reported as contraband. The pest risk involved with most restricted plant material is apparently very small, and for that reason such material has not been considered in this table.

TABLE 23.—*Number of ships inspected, fiscal year 1937*

Port	From foreign ports											
	Direct			Via United States ports			Via Hawaii			Via Puerto Rico		
	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material
Baltimore	728	725	307	788	781	379	1	1	0			
Bellingham	30	30	10									
Boston	1,424	1,423	529	408	407	187				2	2	1
Brownsville	7	7	5	9	9	5						
Brunswick [1]	3	3	2									
Buffalo	7	7	3	1	1	0						
Charleston	208	208	103	152	150	59	1	1	1			
Chicago	5	5	3	11	11	6						
Detroit	26	26	23									
Eureka [2]	2	2	0	4	4	1						
Galveston	278	274	128	468	468	238				2	2	1
Gulfport [2]	21	20	18	105	37	25						
Honolulu [2]	240	240	109	2	2	0						
Houston	427	426	335	437	433	195				1	1	0
Jacksonville [2]	251	251	23	133	133	0				1	1	0
Key West [2]	175	172	72	65	59	1						
Miami [2]	1,381	1,380	419	34	30	14						
Mobile	249	247	106	391	362	187						
New Orleans	1,410	1,410	653	498	498	307				2	2	2
Newport News	82	82	48	419	417	205				1	1	0
New York	3,895	3,899	2,191	1,093	945	444	1	1	0	155	155	105
Norfolk	283	283	153	811	809	372				1	1	0
Pensacola [2]	49	49	26	188	188	87						
Philadelphia	846	845	421	1,079	1,079	608	1	1	1	1	1	1
Port Arthur	326	325	257	324	324	121				7	7	4
Portland, Oreg	69	69	53	270	267	165	1	1	1			
Port San Luis [2]	66	66	14									
Puerto Rico (all ports)	1,013	1,007	353									
San Diego [2]	1,138	1,137	26	24	24	0	2	2	0			
San Francisco [2]	361	361	176	596	596	242	83	83	50			
San Pedro [2]	1,411	1,410	861	363	363	90	72	72	46	15	15	13
Savannah	115	115	68	229	227	128						
Seattle	996	876	137	160	160	91	1	1	1			
Tampa [2]	270	270	88	315	315	95						
Ventura [2]	6	6	1									
West Palm Beach [2]	145	145	5	3	3	0						
Total	17,943	17,711	7,726	9,383	9,102	4,252	163	163	100	188	188	127

TABLE 23.—*Number of ships inspected, fiscal year 1937*—Continued

Port	From Hawaii						From Puerto Rico						From United States ports		
	Direct			Via United States ports			Direct			Via United States ports			Via Panama Canal		
	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material
Baltimore	2	2	0	49	49	1	19	19	1	27	27	0	173	172	6
Bellingham	2	2	1												
Boston				20	20	0	16	16	4				161	161	0
Charleston							8	8	0	19	19	0	40	40	1
Eureka [2]				5	5	0									
Galveston	2	2	0	2	2	1	11	11	2	8	8	0	25	25	0
Gulfport [3]										7	0	0			
Honolulu [2]													100	100	1
Houston	7	7	2	2	2	0	12	12	3	11	11	0	40	40	0
Jacksonville [2]							30	30	0	5	5	0	16	16	1
Miami [2]							2	2	0						
Mobile	1	1	1	4	4	0	29	29	5	53	53	1	45	45	0
New Orleans	12	12	9	10	10	0	22	22	6	76	76	1	51	51	1
Newport News										2	2	0	4	4	0
New York	30	28	2	38	33	0	114	113	12	16	10	1	276	221	3
Norfolk				3	3	0				46	45	1	95	95	0
Pensacola [2]							2	2	0	4	4	0			
Philadelphia	2	2	0	32	32	1	50	50	14	8	8	0	259	259	5
Port Arthur							8	8	2	7	7	0	15	15	1
Portland, Oreg				7	7	1									
Port San Luis [2]	15	14	1												
Puerto Rico (all ports)													15	15	4
San Diego [2]	91	91	10	1	1	0							121	121	10
San Francisco [2]	111	111	33	22	22	2							459	459	6
San Pedro [2]	77	77	15	33	33	7							661	661	81
Savannah				4	4	1	8	8	1	16	16	0	17	15	0
Seattle	2	2	0	1	1	0							2	2	0
Tampa [2]							29	29	2	1	1	0			
Ventura [2]	9	9	1												
Total	363	360	75	233	228	14	360	359	52	306	292	4	2,575	2,517	120

[1] Work handled by inspector stationed at Savannah, Ga. [2] Collaborators stationed at these ports. [3] Work handled by inspectors stationed at Mobile, Ala.

NOTE.—The foreign ship arrivals do not in all cases agree with customs figures. Foreign ships may put in for bunkers and be inspected by inspectors of the Bureau of Entomology and Plant Quarantine but not entered by customs. On the other hand, ships entered at certain small subports are included in customs records but not in this report.

CARGO INSPECTION

All importations of plants and plant products subject to plant-quarantine restrictions are inspected at the port of entry or the port of first arrival. A record of the number of such importations, by ports, appears in table 24.

TABLE 24.—*Inspection of shipments of plants and plant products offered for entry, fiscal year 1937*

Port	Shipments inspected and entered under permit	Shipments refused entry	Port	Shipments inspected and entered under permit	Shipments refused entry	Port	Shipments inspected and entered under permit	Shipments refused entry
	Number	*Number*		*Number*	*Number*		*Number*	*Number*
Baltimore	322	0	Honolulu [4]	557	0	Port Arthur	6	0
Bellingham [1]	208	0	Houston	186	3	Port Huron [4]	75	0
Blaine	300	0	Jacksonville [4]	188	0	Portland	134	2
Boston	2,027	1	Key West [4]	210	0	Presidio	13	0
Brownsville	1,072	0	Laredo	3,229	0	Puerto Rico (all ports)	626	0
Buffalo [2]	1,120	5	Mercedes	17	0	Roma	1	0
Calexico	590	0	Miami [4]	1,120	4	San Diego [4]	5	1
Charleston	149	1	Mobile	207	1	San Francisco [4]	814	17
Chicago	123	4	Naco	8	0	San Pedro [4]	564	0
Del Rio	3	0	New Orleans	2,503	2	San Ysidro	76	0
Detroit	503	12	Newport News	2	0	Savannah	30	0
Douglas	79	0	New York	14,389	71	Seattle	705	1
Eagle Pass	526	0	Nogales	4,869	4	Tampa [4]	1,008	0
El Paso	4,315	0	Norfolk	203	1			
Galveston	206	0	Pensacola [4]	3	0	Total	44,384	130
Gulfport [3]	7	0	Philadelphia	678	0			
Hidalgo	408	0						

[1] Includes entries made at Sumas.
[2] Includes entries made at Niagara Falls.
[3] Work handled by inspectors stationed at Mobile.
[4] Collaborators stationed at these ports.

In addition to the importations credited to the Mexican-border ports, there were several thousand importations of permitted fruits and vegetables which were so small that no duty was assessed by customs and no record of them kept. All of these small importations, however, were carefully inspected before being released.

At certain ports considerable time was devoted to the inspection of miscellaneous cargoes to determine their true status. Many inspections were also made of packing material used with various commodities, to determine compliance with quarantine No. 69. Some time was also devoted to the supervision of the cleaning of shipments contaminated with objectionable material such as soil.

The inspections recorded in table 24 cover plants and plant products imported under the provisions of plant quarantines and regulations as follows:

Regulation 3 of quarantine No. 37: 158,681,159 bulbs, corms, and rootstocks, including *Convallaria*, *Crocus*, *Hyacinthus*, and *Lilium;* 11,227 fruit and nut cuttings, scions, and budsticks; 6,374,790 rose stocks; 85,850 pounds and 2,142 small mail packages of tree and shrub seeds; 3,671,709 pounds of vetch seed; 367,228 pounds of onion sets; 99 test tubes of orchid seedlings; and 347 pounds of miscellaneous propagating material.

Regulation 14 of quarantine No. 37: 6,148,044 bulbs and corms, including 1,884,653 *Gladiolus*, 3,389,193 *Iris*, and 643,902 *Narcissus;* 54,007 plants, bud sticks, and cuttings of a ligneous nature (mostly woody ornamentals), including 10,631 roses; 13,058 dahlia roots; 45,985 orchid plants; 36,575 cactus plants and cuttings; and 365,117 miscellaneous plants, cuttings, etc., not otherwise counted.

Regulation 15 of quarantine No. 37: 155,177 bulbs and corms, including 154,583 *Gladiolus*; 435,396 trees and shrubs, including 17,978 roses; 5,086 dahlia roots; 30 square yards of sod; and 44,648 plants, cuttings, etc., not otherwise counted. Through cooperation of the customs officers stationed at ports of entry along the Canadian border and of the Division of Foreign Pests Suppression, Department of Agriculture of the Dominion of Canada, entry of material

under this regulation was made with adequate safeguards at 27 border ports at which plant-quarantine inspectors are not stationed, as well as at 10 ports where there are inspectors.

Cotton regulations: Cotton, including linters, 360,104 running bales; cotton waste, 210,701 running bales; bagging (second-hand) including cotton-contaminated rags, 205,965 running bales.

Cottonseed products regulations: Cottonseed cake, 18,355,095 pounds; cottonseed meal, 27,639,228 pounds; cottonseed-meal fertilizer, 16,805,532 pounds; mixed feed, including cottonseed cake, 29,919 pounds; cottonseed oil, 43 gallons.

Quarantine No. 8: Cottonseed hulls, 17,196,780 pounds; bolly hulls, 5,127,560 pounds.

Quarantines Nos. 15 and 16: Bagasse, 11,805 pounds.

Quarantine No. 24: Corn, shelled, 5,359,227 pounds.

Quarantine No. 28: Oranges (mandarin), 1,595,724 pounds.

Quarantine No. 41: Corn, shelled, 4,502,799,855 pounds; mixed feed containing shelled corn, 22,220 pounds; corn fodder, 34,000 pounds; corn on the cob, 332,159 pounds; sorghum seed, 4,266 pounds; jobs-tears, 22 pounds; broomcorn, 10,031 bales and bundles; brooms made of broomcorn, 27,257.

Quarantine No. 55: Paddy rice, 93,168 pounds; rice straw, 1,656 bales.

Quarantine No. 56: Bananas 61,940,762 bunches; plantains, 16,192,486 pounds; pineapples, 1,453,670 crates; avocadoes, 10,520,484 pounds; eggplants, 6,342,510 pounds; garlic 7,447,837 pounds; grapes, fresh (not hothouse), 12,966,553 pounds; grapefruit, 8,697,801 pounds; limes, sour, 12,863,643 pounds; peppers, 8,688,265 pounds; tomatoes, 99,346,550 pounds; all other, 93,256,566 pounds.

Potato regulations: Potatoes, 1,971,128 pounds.

PLANTS AND PLANT PRODUCTS ENTERED FOR IMMEDIATE EXPORTATION OR FOR TRANSPORTATION AND EXPORTATION

In addition to plants and plant products affected by the plant quarantines and regulatory orders of the Department which are offered for consumption entry, many products are offered for transportation in bond through the United States and are exported through other ports. Among these are large shipments of Mexican fruits and vegetables entered through Mexican-border ports and exported through ports along the Canadian border. Other shipments arrive at United States ports of entry and are immediately exported therefrom when transportation to their foreign destination is available. Among the products offered for transportation and exportation or for immediate exportation during the year were 117 shipments of nursery stock; 196,424 bales of cotton lint, linters, and waste; 687 bales of bagging; 17,389,947 pounds of cottonseed cake and meal; 25,600 pounds of wheat; 3,313,464 pounds of corn; and 58,145,231 pounds of fruits and vegetables.

With respect to the importation of fruits and vegetables, it should be stated that many shipments which are offered for transportation and exportation in bond are later diverted to points in the United States where consumption entry is made. For that reason shipments of this character require the same care in inspection as shipments offered for consumption entry.

DISINFECTION

Disinfection is required of certain commodities as a condition of entry and of other commodities when inspection reveals the presence of injurious insects or plant diseases. During the year the following plant material was treated under supervision of inspectors of this Bureau: Cotton, 235,408 bales; cotton waste, 117,898 bales; cotton linters, 68,284 bales; parcels of cotton, cotton waste, and bagging, 3,269; bagging, 554 bales; rags contaminated with cottonseed, 1,055 bales; broomcorn, 10,336 bales; rice fiber, 2,116 bales; chestnuts, 1,794 cases; cipollini, 108 cases; corn, 1,000 sacks; vetch seed, 5,877 sacks; other seeds, 88 containers; miscellaneous plants, 598 lots; narcissus bulbs, 371,939; and bulbous iris, 567,351.

In addition to the above, various shipments of plant material and cotton samples were treated at the inspection house in Washington, D. C., as shown in table 27.

AIRPLANE INSPECTION

The importance which the airplane has assumed as a possible means of introducing plant pests is clearly shown by the inspection records for the year. A total of 3,321 airplanes were inspected at the following 17 ports of entry: Douglas and Nogales, Ariz.; Calexico, Los Angeles, San Diego, and San Francisco, Calif.; Miami and West Palm Beach, Fla.; Honolulu, Hawaii; Baltimore, Md.; New York, N. Y.; Philadelphia, Pa.; San Juan, P. R.; Brownsville, El Paso, and Laredo, Tex.; and Seattle, Wash. As a result of these inspections, 1,505 interceptions of prohibited and restricted plant material were taken from 920 airplanes.

These figures represent an increase of approximately 11 percent in the number of airplanes inspected and 29 percent in the number of interceptions made over the fiscal year 1936.

FOREIGN PARCEL-POST INSPECTION

Through cooperation with customs and post-office officials, mail packages from foreign countries which are found to contain plants or plant products are referred to inspectors of this Bureau for examination. Such packages arriving at ports of entry where no plant-quarantine inspectors are stationed are forwarded to the nearest port where inspection can be made.

This activity has continued to increase, as indicated by the total number of packages inspected at all ports, 249,583, as compared with 191,740 for the fiscal year 1936. A record, by ports, of the number and disposition of foreign parcel-post packages inspected appears in table 25.

TABLE 25.—*Foreign parcel-post packages inspected, fiscal year 1937*

Port	Inspected	Refused entry (entire or in part)	Diverted to Washington	Port	Inspected	Refused entry (entire or in part)	Diverted to Washington
	Number	*Number*	*Number*		*Number*	*Number*	*Number*
Atlanta[1]	157	1	120	Miami[1]	154	37	12
Baltimore	2,103	34	238	New Orleans[5]	266	14	83
Boston	5,389	63	2,020	New York	170,986	554	10,115
Brownsville	1,211	6	3	Nogales[6]	656	10	4
Buffalo	1,743	22	316	Philadelphia	8,414	91	849
Chicago	20,893	252	747	Portland[7]	401	11	0
Detroit	4,765	91	146	Puerto Rico (all ports)	53	18	0
Eagle Pass	356	0	0	St. Paul	15,234	40	71
El Paso[2]	687	57	12	San Diego[1 8]	87	8	1
Galveston	1	1	0	San Francisco[1]	5,145	112	16
Honolulu[1]	1,703	212	0	Seattle	2,017	64	7
Houston	138	12	117	Tampa	5	0	2
Jacksonville[1]	113	17	11	Washington	1,497	24	
Laredo[3]	477	51	70				
Los Angeles[1 4]	4,932	101	8	Total	249,583	1,903	14,968

[1] Collaborators are stationed at these ports.
[2] 78 packages were diverted to San Francisco for disposition.
[3] 31 packages were diverted to San Francisco for disposition.
[4] 168 packages were diverted to San Francisco for disposition.
[5] 3 packages were diverted to San Francisco for disposition.
[6] 7 packages were diverted to San Francisco for disposition.
[7] 7 packages were diverted to Seattle for disposition.
[8] 1 package was diverted to San Francisco for disposition.

Following the policy which was adopted some years ago, shamrocks, which are permitted entry through the mails provided they are free from soil, are included in table 25.

Of the number of packages listed as inspected, the following represent shamrocks: Baltimore, 39; Boston, 1,685; Buffalo, 30; Chicago, 5,681; Detroit, 47; Los Angeles, 79; New York, 45,612; Philadelphia, 1,005; St. Paul, 25; San Francisco, 49; Seattle, 95.

There is a marked tendency toward a greater use of the mails for shipping nursery stock and other plants and seeds to this country under the provisions

of quarantine No. 37. Although the relatively large proportion of the importations from Canada and Mexico consist of baggage and cargo shipments, for which the mail-entry procedure is unsuitable (thus tending to keep the percentage of total mail shipments at a relatively low figure), 53 percent of all importations under quarantine No. 37 came by mail. Only 12 percent of the bulb shipments, under regulation 3 of quarantine No. 37, arrived by mail, but 90 percent of all other importations under that regulation were imported by that means. Of the importations entered under regulations 14 and 15 of the same quarantine, 59 percent and 12 percent, respectively, entered through postal channels.

MEXICAN-BORDER SERVICE

With the improvement in economic conditions and the completion of important highways in Mexico, there has been a decided increase in the amount of travel between Mexico and the United States. This increase in traffic is reflected in the increase in the vehicular and baggage inspection at certain ports during the year and also in the number of interceptions of prohibited and restricted plant material. The number of freight cars entering from Mexico increased from 27,259 in the fiscal year 1936 to 32,050 in 1937; likewise, there was an increase in the number of cars contaminated with cottonseed from 1,479 the previous year to 2,034 this fiscal year. The number of railway cars fumigated increased from 8,181 in the fiscal year 1936 to 8,226 in 1937. All railway cars found to be contaminated with cottonseed were required to be cleaned before entry was permitted. The usual fee of $4 was charged for each car fumigated and all fees collected were covered into the Treasury as miscellaneous receipts.

A summary of the railway-car inspection and fumigation is shown in table 26. In addition to the freight cars listed in this table, 4,123 Pullman and passenger coaches entered and were inspected at the following ports: Eagle Pass, 8; El Paso, 1,160; Laredo, 2,487; Nogales, 465; and Presidio, 3.

TABLE 26.—*Inspection and fumigation of railway cars crossing the border from Mexico, fiscal year 1937*

Port	Cars inspected	Cars with cottonseed	Cars entered	Cars fumigated	Fees collected
	Number	*Number*	*Number*	*Number*	*Dollars*
Brownsville	1,261	2	1,258	53	212
Douglas	1,666	3	1,666	60	240
Eagle Pass	2,276	177	2,209	908	3,700
El Paso	7,760	142	7,333	[1] 1,177	4,520
Laredo	12,078	1,520	11,116	4,606	18,924
Naco	716	21	716	3	12
Nogales	7,727	147	7,451	1,366	5,400
Presidio	306	22	301	53	212
Total	33,790	2,034	32,050	8,226	[2] 33,220

[1] Includes 29 cars not from Mexico.

[2] The apparent discrepancy in fees collected and the number of cars fumigated may be explained by the fact that it is customary for the railroads to purchase fumigation coupons in advance.

Plant-quarantine inspectors at Mexican-border ports take an active part, in cooperation with the customs service, in the inspection of vehicles, baggage, personal effects, and express packages from Mexico. A total of 315,736 pieces of baggage and 3,795,609 vehicles were inspected. This inspection resulted in the interception of large quantities of prohibited and restricted plant material, a record of which may be found in table 29.

INSPECTION IN PUERTO RICO AND HAWAII

The inspectors stationed in Puerto Rico enforce the provisions of quarantine No. 58, governing the movement of fresh fruits and vegetables to the mainland, in addition to the enforcement of foreign plant quarantines and regulations

as they affect the entry of foreign plants and plant products into the island. Insular inspectors serving as collaborators render valuable assistance, especially in that portion of the work pertaining to the enforcement of the foreign plant quarantines.

Inspections are made in the fields, in packing houses, and on the docks of such fruits and vegetables as are permitted to move to the mainland under the provisions of quarantine No. 58. During the year 2,817 shipments, consisting of 35 bunches of bananas, 519,631 crates of pineapples, and 17,166,620 pounds of other approved fruits and vegetables were certified for such movement.

Inspection is also made of parcel-post packages originating on the island and destined for points in continental United States. Through cooperation with post-office officials, arrangements were made to carry on this inspection at the four main post offices on the island. This arrangement has increased considerably the efficiency of this phase of the work and has also greatly reduced the number of Puerto Rican mail packages requiring inspection upon arrival at New York. A total of 5,053 packages were examined in the San Juan office, and 337 were found to contain prohibited plant material and were returned to the sender. Inspection figures for the post offices in Mayaguez, Ponce, and Arecibo are not available.

In Hawaii the enforcement of foreign plant quarantines is handled wholly by insular inspectors serving as collaborators. The inspectors of this Bureau stationed in the Hawaiian Islands are engaged in the enforcement of quarantine No. 13, which governs the movement of fresh fruits and vegetables to the mainland. Inspections are made in the fields, packing houses, and on the docks of such fruits and vegetables as are permitted to move to the mainland under the provisions of quarantine No. 13. During the year, 1,728 shipments, representing 71,189 bunches of bananas, 39,443 crates of pineapples, and 3,712,002 pounds of other approved fruits and vegetables, were inspected and certified.

It is necessary to devote considerable time to the inspection of parcel-post packages originating in Hawaii and destined for mainland points. During the year 102,564 such packages were opened and examined and the plant quarantine status of 163,844 packages was determined by other means; 56 packages were found to contain prohibited plant material.

Inspection and sealing of baggage of travelers between Hawaii and the mainland were continued. A total of 3,485 pieces of baggage were safeguarded in this manner.

On November 1, 1936, the inspection and clearing of airplanes bound for mainland ports was inaugurated at the Pearl City airport and on April 10, 1937, inspection of shipments of plant material from Hawaii to the mainland by air express was commenced. This inspection not only avoids delay upon the arrival of the airplanes at the mainland, but also is a decided advantage from the standpoint of pest risk.

INSPECTION OF SPECIAL-PERMIT AND DEPARTMENTAL PLANT MATERIAL

Importations of propagating plant material are inspected at special ports of entry designated for that purpose. Most of these special-permit importations are inspected and treated at the inspection house at Washington, D. C. In addition to special-permit importations, departmental importations and plant propagating material distributed by the Department are likewise inspected at the Washington, D. C., inspection house. The inspection-house staff at Washington also inspects and certifies for interstate shipment commercial shipments of nursery stock, in order that such shipments may meet the certification requirements of the various States. Table 27 gives a summary of inspections and treatments of nursery stock at the Washington, D. C., inspection house during the year.

TABLE 27.—*Summary of plants and plant products offered for inspection in the District of Columbia, fiscal year 1937*

Material inspected	Foreign	Domestic	Fumigated	Otherwise treated	Infested with insects	Infected with diseases
Lots of seeds (departmental)	8,137	9,776	6,944	1,150	656	172
Plants, cuttings, bulbs, roots, rhizomes, etc. (departmental)	11,121	150,495	3,158	3,051	[1] 250	[1] 183
Miscellaneous unclassified material, other than plants and seeds (departmental)	300	365	88	11	7	7
Shipments of plants under regulation 14, quarantine No. 37 (commercial)	2,409	----	405	152	571	485
Shipments of plants and plant products under regulations 3 and 15, quarantine No. 37 (commercial)	1,260	----	214	111	148	26
Containers of domestic plants other than departmental (mail, express, freight, and truck)	----	11,707	1	6	13	4
Shipments of plants by private individuals	----	5,351	15	28	55	14
Interceptions of plants and plant products at Washington, D. C.	1,497	3	35	72	96	----
Interceptions of plants and plant products referred to Washington, D. C.	1,495	1	112	996	111	4
Parcels of cotton samples referred to Washington, D. C.	25,319	----	25,319	----	----	----

[1] Lots.

INSPECTION OF PLANT-INTRODUCTION AND PROPAGATING GARDENS

The Bureau is charged with the responsibility of inspecting plant material at the plant-introduction gardens maintained by the Bureau of Plant Industry where plant introductions are observed and are propagated for distribution. Plant material distributed from the plant-introduction garden at Coconut Grove, Fla., was inspected by State officials cooperating with this Bureau. Plant material shipped from the Chico, Calif., gardens was inspected jointly by an inspector of the Bureau and an entomologist from the California State Department of Agriculture. Material distributed from the District of Columbia and Savannah, Ga., was inspected by inspectors of the Bureau. A summary of the inspections of these plant distributions appears in table 28.

TABLE 28.—*Plants, budsticks, cuttings, tubers, roots, and shipments of seeds examined for distribution from plant introduction and propagating gardens, fiscal year 1937*

Station	Plants	Budsticks, cuttings, tubers, and roots	Shipments of seeds	Station	Plants	Budsticks, cuttings, tubers, and roots	Shipments of seeds
Bell, Md.	29,840	1,025	3	Savannah, Ga.	1,554	677	4
Chico, Calif.	8,337	721	66	Washington, D. C.	8,037	10,185	23,939
Coconut Grove, Fla.	5,633	1,271	28				
Mandan, N. Dak.[1]	0	0	0	Total	53,401	13,879	24,040

[1] Owing to drought no shipments were made.

INTERCEPTIONS OF PROHIBITED AND RESTRICTED PLANTS AND PLANT PRODUCTS

The inspection of ships, vehicles, cargo, baggage, ships' stores, and quarters, and foreign mail at the maritime and Mexican-border ports resulted in the interception of large quantities of prohibited and restricted plant material. Many of these interceptions were found to harbor insect pests and plant diseases; many others, while showing no infestation or infection, must be considered potentially dangerous, since they are known hosts of pests in the country of origin. In classifying the interceptions, those made at bridges, ferries, and crossings at the Mexican and Canadian border ports have all been considered as having been taken from baggage.

A record of the number of interceptions of prohibited and restricted plant material appears in table 29.

TABLE 29.—*Number of interceptions of prohibited and restricted plants and plant products, fiscal year 1937*

Port	In baggage		In cargo		In mail		In quarters		In stores		Total	
	Prohibited	Restricted	Prohibited	Restricted	Prohibited	Restricted	Prohibited	Restricted	Prohibited	Restricted	Prohibited	Restricted
Baltimore	11	15	43	0	38	0	85	8	189	4	366	27
Bellingham	5	10					0	4	3	2	8	16
Blaine	1,059	631									1,059	631
Boston	77	142	4	1	25	42	7	6	10	1	123	192
Brownsville	7,027	1,136			3	3					7,030	1,139
Buffalo [1]	2	360	0	1	9	13					11	374
Calexico	1,841	123									1,841	123
Charleston	13	2	1	0			41	0	30	0	85	2
Chicago			8	0	178	90					186	90
Del Rio	584	83									584	83
Detroit	139	395	3	12	84	29					226	436
Douglas	499	55									499	55
Eagle Pass	1,657	213									1,657	213
El Paso	7,208	942			43	21					7,251	963
Galveston	12	3	1	0	1	0	212	11	24	2	250	16
Gulfport [2]	2	2					11	0	7	1	20	3
Hidalgo	2,242	271									2,242	271
Honolulu [3]	888	258	62	10	187	5			34	1	1,171	274
Houston	4	5	3	0	3	0	433	0	57	0	500	5
Jacksonville [3]					16	0	5	5	17	4	38	9
Key West [3]	86	181					3	1	9	2	98	184
Laredo	15,249	1,347			40	11					15,289	1,358
Los Angeles [3]	4	1	1	7	79	24	4	0			88	32
Mercedes	251	42									251	42
Miami [3]	1,755	450	46	11	27	10	1,016	212	86	11	2,930	694
Mobile	9	3	7	8			127	3	78	4	221	18
Naco	124	44									124	44
New Orleans	444	240	11	19	9	7	843	29	112	7	1,119	302
Newport News							17	0	2	0	19	0
New York	1,815	1,353	514	160	384	75	235	44	139	10	3,087	1,642
Nogales	2,502	813			3	6					2,505	819
Norfolk	3	3	3	0			141	70	45	2	192	75
Pensacola	3	0					24	0	19	0	46	0
Philadelphia	20	7	11	1	66	22	99	43	137	23	333	96
Port Arthur	24	0	1	0			569	2	90	0	684	2
Port Huron [3]	1	138									1	138
Portland			4	0	9	2			8	0	21	2
Presidio	289	45									289	45
Puerto Rico (all ports)	121	46					2	0	1	0	124	46
Roma	173	24									173	24
St. Paul					24	18					24	18
San Diego [3]	8	5			3	0	13	2	46	5	70	12
San Francisco [3]	247	15	21	5	49	58	229	22	122	15	668	115
San Pedro [3]	557	38	4	0			48	0	145	9	754	47
San Ysidro	5,042	584									5,042	584
Savannah							92	1	12	2	104	3
Seattle	81	37	1	0	24	2	1	0	2	0	109	39
Tampa [3]	16	10	1	0			15	7	14	1	46	18
West Palm Beach [3]							6	2	0	1	6	3
Total	52,094	10,072	750	235	1,304	438	4,278	472	1,438	107	59,864	11,324

[1] Includes interceptions made at Niagara Falls.
[2] Work handled by inspectors stationed at Mobile.
[3] Collaborators stationed at these ports.

PESTS INTERCEPTED

During the year the inspectors and collaborators of the Bureau collected from foreign plants and plant products insects belonging to 1,339 recognized species and others distributed among 1,257 genera and families, fungi and bacteria belonging to 313 recognized species, plant-parasitic nematodes belonging to 8 recognized species, and numbers of interceptions of diseases caused by fungi, bacteria, nematodes, or other agents that could be referred to family, genus, or other group only. Many of these interceptions were of considerable economic or scientific importance.

A total of 86,703 interceptions of insects and plant diseases were made during the year. A summary of the interceptions appears in table 30.

TABLE 30.—*Number of interceptions of insects and plant diseases made during the fiscal year 1937*

Port	Cargo		Stores		Baggage		Quarters		Mail		Total	
	Insects	Diseases	Insects	Diseases	Insects	Diseases	Insects	Diseases	Insects	Diseases	Insects	Diseases
Baltimore	571	60	394	348	3	3	70	21	57	20	1,095	452
Bellingham	12	10	0	0	0	0	0	0	0	0	12	10
Blaine	3	4	0	0	9	7	0	0	0	0	12	11
Boston	111	59	298	280	95	28	36	21	49	25	589	413
Brownsville	3,078	91	10	9	9,011	400	98	0	0	0	12,197	500
Buffalo	36	93	0	3	4	1	0	0	29	6	69	103
Calexico	2	0	0	0	96	2	0	0	0	0	98	2
Charleston	498	6	12	21	0	0	0	1	0	0	510	28
Chicago	6	3	1	1	0	0	1	0	46	8	54	12
Del Rio	0	0	0	0	379	2	0	0	0	0	379	2
Detroit	33	45	7	4	5	2	0	0	21	4	66	55
Douglas	0	16	0	0	13	3	0	0	0	0	13	19
Eagle Pass	520	71	0	0	510	63	0	0	0	0	1,030	134
El Paso	634	82	0	0	796	286	0	0	12	2	1,442	370
Galveston	1,196	4	73	215	1	0	13	3	0	0	1,283	222
Hidalgo	180	15	0	0	1,632	466	0	0	0	0	1,812	481
Honolulu	162	2	20	0	142	7	273	8	147	2	744	19
Houston	30	6	38	980	0	0	7	7	4	1	79	994
Jacksonville [1]	19	8	18	91	5	0	8	3	2	2	52	104
Key West [1]	1	0	1	0	6	0	1	1	0	0	9	1
Laredo	4,017	51	2	0	2,944	63	0	0	10	0	6,973	114
Los Angeles [1]	0	0	0	0	0	0	0	0	30	1	30	1
Mercedes	11	0	0	0	931	51	0	0	0	0	942	51
Miami [1]	229	12	75	32	412	40	169	9	16	7	901	100
Mobile [2]	723	10	115	392	5	5	47	6	0	0	890	413
Naco	3	1	0	0	37	9	0	0	0	0	40	10
New Orleans	4,696	148	153	301	44	11	149	20	19	3	5,061	483
Newport News	13	0	26	147	0	4	0	1	0	0	39	152
New York	5,640	6,993	3,893	1,735	1,671	767	789	121	1,762	162	13,755	9,778
Nogales	4,099	1,566	0	0	716	134	0	0	4	0	4,819	1,700
Norfolk	374	69	202	937	0	2	24	13	0	0	600	1,021
Pensacola [1]	0	0	17	14	1	0	9	0	0	0	27	14
Philadelphia	186	393	305	1,118	12	14	93	88	115	71	711	1,684
Port Arthur	14	0	173	455	1	0	95	5	0	0	283	460
Portland	2	3	8	6	0	0	2	2	3	1	15	12
Presidio	0	0	0	0	49	0	0	0	0	0	49	0
Roma	3	0	0	0	36	12	0	0	0	0	39	12
San Diego [1]	6	0	26	6	0	0	3	0	3	0	38	6
San Francisco [1]	2,309	490	127	19	620	24	196	8	660	210	3,912	751
San Juan	33	8	10	3	36	0	0	0	12	0	91	11
San Pedro [1]	277	2	171	59	147	4	6	0	0	0	601	64
San Ysidro	21	0	0	0	42	6	0	0	0	0	63	6
Savannah	68	0	21	61	0	0	6	3	0	0	95	64
Seattle	464	36	78	28	103	25	72	6	78	25	795	120
Tampa [1]	3	0	14	34	5	6	3	0	0	0	25	40
Washington, D. C.	896	425	0	0	542	110	0	0	1,077	315	2,515	850
Total	31,179	10,781	6,288	7,299	21,061	2,557	2,170	347	4,156	865	64,854	21,849

[1] Collaborators stationed at these ports.
[2] Includes interceptions at Gulfport, Miss.

NOTE.—Inspectors stationed at Puerto Rico made 48 interceptions of insects and 2 interceptions of plant diseases during their field and packing-house inspection of fruits and vegetables for shipment to the mainland.

CERTIFICATION FOR EXPORT

During the year 7,409 certificates, covering 2,780,569 containers of plants and plant products, were issued. This represents a decrease of 1,690 in the number of export certificates issued and of 959,926 in the number of containers certified compared with the figures for the fiscal year 1936. This decrease was largely due to the falling off in the quantities of apples and potatoes exported under certification.

Export certificates were issued at 32 ports, covering 61 different commodities which were exported to 63 foreign countries. Some of the more important commodities inspected and certified were: Apples, 1,945 shipments, consisting of 1,112,194 boxes, 32,278 barrels, and 13,982 baskets; pears, 1,021 shipments, con-

sisting of 633,698 boxes; potatoes, 992 shipments, consisting of 390,139 bags, 12,442 crates, and 9,472 barrels; oranges, 705 shipments, consisting of 328,132 boxes.

Many shipments of apples and pears were certified under a cooperative arrangement with the Bureau of Agricultural Economics of the Department, whereby licensed inspectors of that Bureau located at shipping points make inspections and issue reports which are accepted by the plant quarantine inspector at the port of export as a basis for issuing the required export certificate.

A brief summary of the export certification work appears in table 31.

TABLE 31.—*Certification for exportation, by ports, fiscal year 1937*

Ports	Certificates issued	Total containers certified	Commodities certified	Foreign countries	Ports	Certificates issued	Total containers certified	Commodities certified	Foreign countries
	Number	*Number*	*Number*	*Number*		*Number*	*Number*	*Number*	*Number*
Baltimore	35	11,673	3	2	New Orleans	54	3,682	12	4
Boston	1	1	1	1	Newport News	2	47	1	1
Brownsville	18	8,533	3	1	New York	4,007	836,751	42	49
Buffalo	2	470	1	1	Nogales	87	489	7	1
Calexico	26	30,847	5	1	Philadelphia	4	4	1	4
Chicago	2	2	1	2	Port Arthur	2	17,418	1	1
Detroit	37	455	4	4	Portland	698	414,989	8	15
Eagle Pass	1	30	1	1	San Diego	1	2	1	1
El Paso	90	1,140	9	1	San Francisco	223	105,413	12	12
Galveston	5	6	1	1	San Juan	12	61	5	8
Hidalgo	25	270	6	1	San Pedro	596	282,034	4	6
Houston	2	247	2	2	Savannah	1	60	1	1
Jacksonville	5	8,443	3	1	Seattle	1,360	1,040,440	12	12
Laredo	23	12,349	3	1	Tampa	4	21	1	2
Los Angeles	73	3,674	8	3	Washington, D. C.	8	12	1	1
Miami	3	1,000	1	1					
Mobile	2	6	1	2	Total	7,409	2,780,569	------	------

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